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UNITED STATES DEPARTMENT OF AGRICULTURE
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Bureau of Entomology and Plant Quarantine

RESULTS OF CODLING MOTH INVESTIGATIONS, 1943

Part I

Report of the Committee on the Codling Moth

Work Conducted by State Agencies,
Entomological Branch, Canadian
Department of Agriculture
and
Commercial Entomologists

Not for Publication

This pool of information on the results of codling moth research for the season of 1943 is the eleventh of a series of similar summaries prepared annually by the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture, at the request of the Committee on the Codling Moth of the American Association of Economic Enomologists. These data are assembled for the confidential information of workers who are interested in the codling moth problem. The material is not for publication and is therefore not available for quotation or other use without specific permission from the agency which has furnished it.

Although an invitation to submit material for inclusion in the pool was forwarded a year ago to workers in the Union of South Africa who had expressed a desire to cooperate, their contribution has not yet been received. A further invitation has been sent to these workers and any data received during the year will be issued as a supplement to Part I of this pool.

REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1943

Byrley F. Driggers, L. G. Gentner, Edwin Gould,
W. S. Hough, George M. List, L. F. Steiner, Chairman.

In recent years the Committee on Codling Moth has sponsored conferences of workers interested in codling moth control and has arranged with the Bureau of Entomology and Plant Quarantine for the collection, preparation, and redistribution of an annual pool of information on current research. In 1941 and 1942 the Committee also suggested those lines of research which it considered most important.

By correspondence your Committee has voted unanimously against having a conference this year. Members of the Committee were all agreed however, that the pool of information was of very great value to all workers and should be continued and arrangements were again made with the Bureau of Entomology and Plant Quarantine for its collection, preparation and distribution. This is the eleventh in an unbroken annual series and the Committee hopes that all codling moth investigators or research organizations in Canada and South Africa as well as the United States will contribute to the pool.

The majority of the Committee feels that the suggested lines of codling moth research given in the 1942 report should be again presented with some slight revision. These suggestions follow.

1. Abstract all published information on codling moth studies and observations and make copies of the complete abstract available to those persons interested in codling moth research. It is suggested that the Bureau of Entomology and Plant Quarantine take the lead in this undertaking.

2. Continue research on substitutes for lead arsenate. This compound is inefficient in regions where codling moth injury is severe, is often injurious to fruit and foliage and has been suspected of reducing the set of fruit. Scarcity of the basic materials from which lead arsenate is manufactured during the war period is an added reason for continuing and intensifying the search for substitutes, with special emphasis on nicotine bentonite.

Studies of methods of fortifying lead arsenate as a larvicide should continue with emphasis on the development of chemicals that can be added to lead arsenate sprays to destroy other stages of the insect, particularly the egg and adult.

3. The Committee feels that more attention should be devoted to the study of ways and means of destroying the overwintering larvae and spring pupae; that this is a field of study which has barely been touched upon and if a reasonable proportion of the total research work now being done was devoted to this phase of the problem worth while results might be obtained.

4. Further attention should be given to the evaluation of strains within regional orchard areas. Studies are also needed to answer the question: Can quick acting stomach poisons or contact insecticides lead to the development of resistant or hardier strains?

5. Fundamental studies are needed on physiology with special emphasis on the way insecticides destroy the different stages of the insect or influence the population. In this connection the effect on larvae already inside the apple should not be overlooked. Is the reproductive capacity of the insect or its rate of development affected? Some of the many new materials being tested as insecticides (usually only as ovicides and larvicides) may have entirely unsuspected effects in other ways that might be overlooked.

6. In studies on the habits and behavior of the insect special emphasis should be placed on (1) the relation of the time of moth emergence or moth flights and the time when peaks of larval attacks actually occur, (2) the effects of specific insecticides and adjuvants on the behavior of larvae, adults and natural enemies. Such effects as repellency and attractiveness to adults or larvae might increase or decrease control in limited tests but have little or no effect in large areas. It is also possible that changes in behavior might make the insect more susceptible to other means of control when used in conjunction with a particular insecticide.

7. The reasons for differences in the relative control value of certain insecticides in different regions should be given more attention. It is generally assumed the differences are largely caused by climate, but just how are they responsible? Conflicting reports from different workers may reduce confidence in research unless regional differences are known to exist and their importance emphasized.

8. Codling moth research may be improved by the development of more reliable technique in order to make it possible to evaluate properly the many variables with which we must contend. Some workers are limited by time and funds and yet are under extreme pressure for results and cannot give much attention to the ideal technique, or even use reliable technique if it requires more work. For this reason, the publication of results should give adequate information concerning methods so that others can at least estimate the reliability of the results.

9. The possibilities of biological control should receive more attention.

10. The majority of the Committee feels that entomologists have not taken due advantage of the factor of climate, particularly temperature, in the over all problem of codling moth control. It is common knowledge that in nearly every apple growing state or region there are areas or zones of intensity of codling moth attack. The intensity of attack is generally related to the number of broods per season and this in turn is governed to a large extent by the mean annual temperature during the apple growing season. Thus we find different areas where the codling moth is one, two, three or even four brooded and it is in the three and four brooded areas where the greatest difficulty in control is experienced. It is suggested, therefore, that entomologists in collaboration with horticulturists consider the advisability of gradually shifting apple production from the three and four brooded areas to the one and two brooded areas.

11. Entomologists should give more attention to the problem of rotation of apple plantings, either by rotating apples with apples or apples with other fruits, as a factor in the control of codling moth. This would seem to be particularly worthy of study in the three and four brooded areas. It is a general observation that codling moth is more easily controlled on younger and smaller trees. In this connection it would seem worth while to study the possibilities of the dwarf and semi-dwarf stocks in areas of severe codling moth attack.

12. There is a need for additional work by entomologists in cooperation with agricultural engineers and spray equipment manufacturers looking toward the development of more efficient machinery for applying sprays. One of the big items in the cost of apple production is the labor and equipment necessary to apply the number of sprays found necessary for adequate control with existing spray combinations.

The Committee will welcome any suggestions from members of the Association regarding ways in which its usefulness can be increased.

CALIFORNIA

A. D. Borden, California Agricultural Experiment Station, Berkeley

I Seasonal condition and status of infestation.

Though the bait trap records showed a sharp increase in the number of moths taken during the first brood flights the cool temperatures during May and early June apparently lessened the attack. The recommended programs where properly timed and applied gave satisfactory control.

III. Results of control experiments. Due to war conditions and lack of assistants no extensive experiments were undertaken. Most of our effort was given in demonstrational work and in assisting the growers in the proper timing, mixing and application of their sprays.

A. Control by insecticides.
(1) Lead arsenate

In two large Bartlett pear orchards heavily infested with codling moth a straight standard lead arsenate program with powdered commercial spreaders gave excellent control with six sprays. No oil was used as an ovicide in any of the applications.

For the second year an experimental plot was run on Payne walnuts infested with codling moth. These were timing experiments and included five treatments (unsprayed check included) in which 4# Basic lead arsenate and an oil spreader were used on five single tree replicates. In 1943 two sprays properly timed gave 4% wormy nuts and the check 19% wormy. These were demonstrational orchards.

c. Xanthone used in a demonstrational way in last two sprays on apples and pears gave excellent control of late codling moth and prevented injury to foliage by mites. Dosage of 2# Xanthone, 6 ozs. Colloidal #77, 1 pint kerosene per 100 gallons used. Xanthone is very promising for use in California in last two applications as it controls codling moth and mites and replaces oil-lead arsenate combinations which interfere with spray residue removal when applied as preharvest sprays.

d. Other organic materials. Dow DN-111 was used extensively on pears in last two sprays for control of mites. Half pound dosage added to lead arsenate spray gave temporary relief from mite injury near harvest but mites increased rapidly after harvest.

IV. Experience of growers in obtaining insecticides and spray equipment during 1943. Limited number new equipment available. Sufficient insecticides available though growers experienced much difficulty in obtaining suitable commercial spreaders. Changes in formula of spreaders made it difficult to obtain spray deposits of past seasons.

CONNECTICUT

Philip Garman, Connecticut Agricultural Experiment Station, New Haven

I. Seasonal conditions.

Seasonal conditions in Connecticut apparently favored codling moth in 1943. July and August were both warm and dry so that infestations increased decidedly over 1942. The trouble this year seems to have been mainly along the southern border of the State, near Long Island Sound.

III. Control experiments.

Lead arsenate:- Continued experimentation with increased amounts of lead arsenate in fewer sprays continued to give good but not perfect results. Fermate plus oil plus alumina gel and lead arsenate was used this year. Scab and other disease control was equal to more extended programs. Curculio control was not quite so good, but codling moth and apple maggot control were equal to or better than the more extended programs. Comparisons were made between three and five summer sprays or between four and six. Check on arsenical load carried by the foliage indicated much greater amounts of arsenic throughout the season for the reduced schedule - increased arsenical plots.

Cryolite:- In connection with other work we noted the very poor codling moth, curculio, and maggot control wherever cryolite was used in place of lead arsenate. This was believed due to poor adhesion since it was necessary to use a fungicide and observations indicated very rapid removal by rains for such combinations as cryolite and wettable sulfur.

DELAWARE

Paul L. Rice, Delaware Agricultural Experiment Station, Newark.

I. Seasonal conditions and status.

The light crop of apples over most of the State made codling moth control particularly difficult in 1943. Consequently, a lower percentage of clean fruit than usual was produced. Because of the high price, however, growers received good financial returns from even the lower market grades. A considerable number of the growers are now using nicotine sulfate to combat the adult moths at the peaks of their activity. The results from its use, as a whole, are encouraging.

III. Control experiments.

Cooperative work was carried on between the Departments of Plant Pathology and Entomology of the Delaware Station in attempting to evaluate three different types of spray equipment in codling moth control. The equipment used was (1) a vertical boom attachment consisting of a battery of six guns fastened at varying heights to a supporting rod rising vertically from the rear of the spray machine to a height of 17 1/2 feet from the ground, (2) the "Speed Sprayer," and (3) two eight-nozzle brooms (one operated from the ground and one from a tower). Six plots, of about 140 trees each, were included in the experiments. Six trees used as checks were not sprayed after the first cover spray.

Each type of equipment was used in spraying two plots. All plots were sprayed with the same equipment during the application of the first cover spray, but the different types of equipment were used on the seven succeeding sprays. Due to high codling moth populations and an extremely light crop of fruit, very poor control was obtained.

A summary of the degree of codling moth control resulting from the use of the various types of equipment follows (Table I):

TABLE 1. Comparison of three kinds of spray equipment used in codling moth control; Cheswold, Delaware, 1943.

Equipment	Percent clean apples	Percent wormy apples	Percent stung apples	No. worms per 100 apples	No. stings per 100 apples
Vertical boom	16.3	20.2	63.6	30.3	217.9
"Speed Sprayer"	8.4	25.8	65.9	42.2	343.2
8-nozzle brooms	12.2	34.0	53.9	57.2	332.8
Check*	5.6	70.3	24.1	137.7	281.4

*Unsprayed after first cover spray.

When the degree of worminess is used as an index there is an indication that the vertical boom gave the best control, the "Speed Sprayer" next best, and the brooms the poorest control. However, these differences were not statistically significant.

Observations on arsenical deposits likewise give evidence of superior coverage with the vertical boom equipment. Leaf samples taken at the outside bottoms and outside tops of the trees showed arsenical deposits with a relationship of 1.00 bottom to 1.02 top for the vertical boom, 1.00 bottom to 0.82 top for the "Speed Sprayer" and 1.00 bottom to 0.99 top for the brooms. From the data it appears that the vertical boom and the brooms give a more even coverage from top to botton than the "Speed Sprayer."

The arsenical deposit on foliage from the outside top leaves was compared with that adhering to the inside top leaves. This was done in order to get a comparison of the penetration of the sprays from the three kinds of equipment. The results of this analysis are given in Table 2.

TABLE 2. Arsenical deposits on foliage samples obtained from outside and inside top areas of trees sprayed with different kinds of equipment; Cheswold, Delaware, 1943.

	Deposits of As_2O_5 per square inch	
Equipment	Outside top sample	Inside top sample
Vertical boom	318.2	262.3
"Speed Sprayer"	261.5	171.6

*Figures are averages of three sets of samples taken at different times during the summer.

The data in Table 2 give definite indications that the vertical boom equipment produces a superior penetration of the spray into the inside top regions of the tree. This finding correlates with the indications of better codling moth control from the use of this equipment.

IV. Experience of growers in obtaining insecticides and spray equipment during 1943.

Growers have had little difficulty in obtaining insecticides and spray equipment. As a whole, the situation in this regard is satisfactory.

GEORGIA

W. H. Clarke, Fruit Pest and Parasite Laboratory, Georgia Department of Entomology, Cornelia.

1. Seasonal Conditions and Status of codling moth infestations during 1943.

Spring brood emergence of moths was lighter in 1943. A total of 452 moths were caught in 5 bait traps placed in the same location as the previous year when 2,021 moths were caught. The peak number was 88 moths of the spring brood taken on May 4th as compared with 549 on April 27th in 1942.

A late freeze occuring on April 15 and 16 killed out all but the last buds and the crop set and gathered was light, probably not more than a 15 percent crop. Codling moth infestation in harvested fruit was somewhat heavier as a result of the light crop.

2. Studies on codling moth biology and behavior.

Stung apples were collected for each brood of the codling moth and records were made on larval emergence, pupation, and emergence of adults and parasites. The parasite emergence was very low and the only one of importance recovered was the larval parasite *Ascogaster carpocapsae*.

3. Control experiments.

No insecticide control experiments were conducted during 1943.

4. Experience of growers in obtaining insecticides and spray equipment during 1943.

Growers were able to obtain all the insecticides needed for the control of fruit insects, but did have difficulty and costly delays in obtaining repair parts for spray equipment.

ILLINOIS

S. C. Chandler, Illinois Natural History Survey, Carbondale.

I. Seasonal conditions and status of codling moth infestations during 1943.

The 1943 season started under somewhat more favorable circumstances than did 1942. Carry-over was lighter and a period of cool rainy weather early in the season was very unfavorable for codling moth development. Hot dry weather the latter part of the season, however, was very favorable for codling moth development. The heaviest attack came the last week in August and the first week in September. Heaviest attacks occurred in orchards in which the earlier broods had not been sufficiently reduced by spraying and in orchards subject to infestation from outside sources. A very big increase occurred in orchards in which much of the deposit of poison had been reduced. The average percentage of wormy apples in an orchard survey of 28 blocks of apples was 12.6 per cent, which was almost the same as in those same orchards a year ago, namely 13.0 per cent. Infestations were not quite so severe in central Illinois as in southern Illinois, since the heavy attack started earlier in the south but was stopped about the same time in all latitudes by cold weather in September. In the northern part of the State, where one brood and a part of a second is normal, a heavy second brood occurred and a greater than normal carry-over is present in that area.

III. Results of control experiments.

A. Control by Insecticides

Use of a Safener for Lead Arsenate

A test designed to run for three or more years was begun to determine the value of the zinc oxide preparation, "Safe-N-Lead," manufactured by the Sherwin-Williams Company. Five rows of mature apple trees (18 to 20 years old) 30 trees long were sprayed with the regular lead arsenate schedule, but Safe-N-Lead, 1 pound to 100 gallons was used in place of lime or weak bordeaux. A block running parallel, separated by a narrow swale, received the standard lead arsenate schedule, the grower using lime as a safener because of the danger of russeting on this variety, Jonathan. Jonathan was selected because of the greater probability of injury. A calyx and six lead arsenate applications were given, the last four with summer oil.

Three pounds of lead were used per 100 gallons in the calyx and in the 5th and 6th covers, and 4 pounds in the 1st to 4th covers inclusive. Equal parts of lime were used in the standard block. Final infestation counts were made of picked apples (drops were very few) with the final results as follows:

Total Apples Examined	Plot, Treatment	Injury at Calyx End	Codling Moth Entered	Codling Moth Stung
1,000	Safe-N-Lead	359	7	29
1,000	Lead-Lime	132	5	32

Use of Dinitro Mixture "C" With Lead Arsenate

Upon request we located a grower who would use Dinitro Mixture "C" (50% ammonium dinitro ortho cresylate and 50% talc) with his regular lead arsenate sprays at the recommended strength, 2 ounces to 100 gallons of water. This material was used in the five lead arsenate cover sprays which were applied, from May 10th to June 9th inclusive, on a block of Rome Beauty trees about 18 years old, 4 rows wide and possibly 40 trees long. This plot was compared with 4 rows separated from the above by an open space of 4 rows, in which replants were growing. Lead arsenate was used at the rate of 4 pounds to 100 gallons, with 3 pounds of lime and 1/4 pound of soy flour. In both blocks three applications of Black Leaf 155 with summer oil were made, but the dinitro mixture was not used in these nicotine sprays. Final infestation counts were made on the trees just before harvest, and 1,000 apples were examined, with the following results:

Dinitro plot, 5.4 % entered, 16.0 % stung.
Standard plot, 4.2 % entered, 14.0 % stung.

The following test was suggested by the late Professor Flint as a grower's test of lead arsenate compared with fixed nicotine. The tests were conducted by a grower, under our supervision, who had changed from lead to nicotine over his entire orchard except for the "lead block" of about 100 trees, 22 year old Staymans and Yorks. Comparisons were made in counts and observations with the same number of adjacent rows. Both blocks received exactly the same number of applications on the same dates or within a day of it. As seen by the results, additional nicotine applications should have been given in the nicotine blocks to offset the longer period of efficiency of lead arsenate. The spray schedule was heavy, consisting of a calyx and 9 cover sprays, beginning April 28th, and

ending August 24th. In the nicotine block tank mixed nicotine was started in the second cover, with a change of material to Black Leaf 155 in the 6th cover. The dates of application on which sprays were started were as follows: Calyx, both sides, April 28th; inside trees, April 30; topoff May 1; covers on May 4, 12, 19, 26, June 3, July 5, 19, August 3, and 24. The last application in the lead plot was with Black Leaf 155 and oil. Final infestation counts of picked apples (few drops) were as follows:

Plot	Variety	Apples Examined	Apples Entered	Apples Stung
Lead Arsenate	Stayman	700	9 (1.3%)	54 (7.7%)
Nicotine	Stayman	700	49 (7.0%)	29 (4.1%)
Lead Arsenate	York	700	2 (.3%)	37 (5.3%)
Nicotine	York	700	24 (3.4%)	40 (5.7%)

B. Control by means other than spraying.

Much of the work of the season on codling moth has consisted of a survey of 13 orchards in southern Illinois. This survey was begun in 1942 and will probably be continued one more season. It consists of weekly observations on methods of spraying, materials used, spray equipment, orchard sanitation and other factors which might solve the problem of why some growers succeed in controlling codling moth and others fail in the same area. While these cannot be classed as experimental data, they have already brought out some very important facts. One of the most important of these concerns the importance of orchard sanitation, and indicates that control measures, other than spraying are even more important than we have considered them before. To date it appears that the growers who consistently practice thorough orchard sanitation year after year, regardless of the general level of infestation, have the fewest number of wormy and stung apples and can get good results with the minimum number of spray applications.

IV. Experience of growers in obtaining insecticides and spray equipment during 1943.

Most growers have been able to secure all spray insecticides necessary except soybean oil and pyrethrum (the latter not needed to any extent). Spray equipment has been very difficult to get, but not nearly so difficult as growers were first told it would be, and in the main they have got by well enough.

INDIANA

G. Edwin Marshall, Purdue University Agricultural Experiment Station, Orleans

This report gives in detail the treatments and results of nine spray schedules carried on at the Elrod and the Experimental orchard for the purpose of studying new and promising spray schedules for codling moth control.

The most interesting spray treatment studied from the standpoint of residue analysis and worm control is the one designated as plot four of table 3. This plot at the Elrod orchard received three lead arsenate-oil-soap sprays which were applied May 25, June 4, 5 and 19. These were followed immediately by a spray of flocculated bentonite June 21 and 22 with another of the same material July 2, 3 and 6. On August 4 the last flocculated bentonite application was applied as a top-off spray. September 1 and 2 a spray of a half percent oil was applied as an ovicide. Thus the last lead arsenate went on June 19. Table 1 gives the residue story for the varieties given this treatment.

If a comparison is made using the residue figures in table 1 and table 2 it will be seen that the before harvest arsenic figure is almost as high on plot 4 as on plot 2. The date of the last spray containing lead arsenate on plot 4 was June 19, whereas on plot 2 it was July 12 and 13. In the past we have found evidence that flocculated bentonite did much to aid in codling moth control when used after lead arsenate. It seems probable that it aids in the retention of the lead and arsenic residue on the foliage and fruit, acting as a protective coating over the arsenate of lead residue. These residue figures seem to bear this out.

The foliage from these plots (table 3, plot 4) began dropping a little earlier than from the lead arsenate treatments. This is also true of the tank-mix schedule (plot 1). Fruit which is not washed will shrivel earlier when coated with bentonite residues than with lead arsenate. Observations of the use of water safener (tri-sodium phosphate) in the washing solution suggests its use for the easy removal of bentonite residues.

Next in interest in the Elrod spray plots from the residue standpoint are the schedules 2 and 2A (See table 2). In both of these it will be noted zinc sulphate was used as a safener for the lead arsenate but in one, lime was used to make a so-called zinc bordeaux while in the other lime was left out of the schedule. Worm control attained in these plots tend to bear out the same trend although there is not enough difference between the two treatments in worm control on Winesap to offer assurance either way.

The zinc sulphate was put in the schedule as a safener for lead arsenate to prevent foliage injury and this suggestion was formerly made by the Ohio Experiment Station. Furthermore, the lime was added to zinc sulphate in one schedule to produce a zinc bordeaux also suggested by the Ohio Station. However, the writer through former work has found too little difference, between schedules, including lime and those in which it was withheld, to warrant putting it in. This year's observations on foliage would seem to substantiate former findings with the proponderance of evidence favoring the use of lime with zinc sulphate from the standpoint of worm control, residue retention, and foliage condition. It may be said with certainty that as far as the safety of the foliage is concerned, if zinc sulphate and lime are to be used these materials should be included in several sprays rather than just two.

Reference to the commercial schedule used at the Experiment orchard (table 4) will reveal that it was very similar to plot 2A at Elrod's orchard. Foliage and fruit conditions as well as control were satisfactory at harvest time. Residue analysis also shows the similarity of the two programs.

Table 3 is a detailed record of the plot treatments at Elrod's. It should be remembered that very special care was exercised in choosing the treatment to be applied in this orchard in 1943. This was prompted by wartime needs for apples. To accomplish this and to make certain that every effort was extended toward growing a worm-free crop the writer personally supervised every application of each plot to see that the tops of the trees were well sprayed and that the girls who sprayed the under sides of the trees and the outsides from the ground were doing a thorough job. The four schedules selected for use were those which had been studied thoroughly as one tree plots on several varieties. Treatment four of the schedules was developed at this laboratory. Treatment one was developed pretty largely by L. F. Steiner and associates at the U. S. Deciduous Fruit Insect Laboratory at Vincennes. Treatments 2 and 2A are outgrowths of the Ohio Agricultural Experiment Station's research under Dr. C. R. Cutright. This latter schedule has been modified in various ways by the writer as seemed necessary to best meet the needs of sprays for southern Indiana. Treatment 3 is a schedule suggested by the Tobacco By-Products and Chemical Corporation.

It may be said of each of these programs that they controlled codling moth satisfactorily even though the attack by this insect, as

recognized by the writer and Orange and Lawrence County growers, was about as heavy as it has ever been. The very fact that we are able to make this statement this year is overwhelming evidence that we now have several programs using lead arsenate and at least two or three containing no lead arsenate which will control the heaviest infestations of the codling moth. The Elrod orchard is recognized as having as great a moth population as any in this state. The fact that control was attained this year adds weight to the statement that "now any grower can control the codling moth satisfactorily if he will use the knowledge available." No such statement could be made a decade ago.

Table 5 is self explanatory. Such cost figures have never been computed in this orchard heretofore. To most readers who have looked at them they do not arrange themselves as might be expected after a survey of the schedule applied. This is especially true from the standpoint of growers who have discussed the matter with the writer. The one feature in this table which makes it worth some study is the fact that the inter-relationship between cost of materials and application on the one hand, and codling moth attack cost on the other has been expressed in the final figures in the columns headed as "Net". The net figure for each treatment represents the earnings after the cost of materials and application having been arrayed separately, and the reduction in price caused by the codling moth attack likewise arrayed, had been deducted from the original value of the worm-free crop. A study of these figures together with reference to table 3 will reveal that treatments 2 and 2A were the most expensive and that this is because stings were so heavy in these two plots. Plot 3 costs were about twice as much in labor as any other treatment and almost twice as much for spray materials, yet this treatment controlled so well that but little had to be charged off as codling moth damage.

Such a table would be an excellent one to consult in attempting to decide what spray schedule to use on a commercial orchard. In doing so however, the production record of the orchard concerned should be kept uppermost in mind. This was the "ON" year at the Elrod orchard. If the production had averaged less than 15 bushels per tree the net earnings would have been less; less because the spray materials and labor bills would have been just as large and because the codling moth attack would have been the same but concentrated on fewer apples. This would have reduced the amount of fruit free from worms and stings. By the same manner if the crop from these trees had averaged more than 15 bushels the net earnings would have been greater.

A note of warning is most justifiable here. Four years ago U. S. No. 1 apples sold for 85 cents per bushel. If such were the condition of the apple market this year or if such conditions prevail again in the future the value of worm free fruit from these 50 tree plots would be $637.50 instead of $2625.00, the figure this year. After glancing down column seven of table 5 (cost of codling moth damage, spray materials and labor) and recalling that to this cost we must add four scab sprays, a calyx and a calyx top-off application most years, pruning, picking, packages and packing, fertilizer, orchard culture costs, scraping and banding we immediately realize that no grower could operate under such conditions.

The plot treatments and the measure of control attained at the Experimental orchard are shown in table 4. Unlike those at Elrods these plot treatments are not maintained for the purpose of proving the practicability of certain schedules but rather for the purpose of studying new materials and schedules which seem to offer promise after having been studied by Mr. Ford from a chemical point of view and by the writer.

During the 1943 season attention was directed toward the use of five different carriers of nicotine (as Black Leaf 155) in an attempt to find something that would make nicotine more effective over a longer period than has been the case when used as it is at present. For these studies three varieties of apples were used with two single tree plots of each making six trees in all. On plot five only, was the foliage injury severe. Fruit drop began first on the plot receiving bentonite as was true at Elrods.

Table 1. Mid-season and harvest residue analyses of Plot 4 at Elrods.

Sample Number	Variety	Date Picked	Gr. lead per lb. if apples had been of average weight	Gr. Arsenic per lb. if apples had been of average weight
5406	Winesap	July 26	0.294	0.134
5407	Jonathan	July 26	0.115	0.071
5414	Winesap	Sept. 18	0.078	0.042
5408	Jonathan	Sept. 18	0.099	0.055
Tree top 5409	Jonathan	Sept. 18	0.019	0.029
Bottom of tree 5410	Jonathan	Sept. 18	0.132	0.072

Table 2. Mid-season and harvest residues on Plots 2 and 2A at Elrods.

Sample Number	Variety	Date Picked	Gr. lead per lb. if apples had been of average weight	Gr. arsenic per lb. if apples had been of average weight
5402 with lime	Winesap	July 26	0.247	0.149
5404 no lime	Winesap	July 26	0.163	0.119
5403 with lime	Jonathan	July 26	0.148	0.081
5405 no lime	Jonathan	July 26	0.163	0.081
5415 with lime	Winesap	Sept. 18	0.255	0.113
5413 no lime	Winesap	Sept. 18	0.184	0.101
5412 with lime	Jonathan	Sept. 18	0.330	0.225
5411 no lime	Jonathan	Sept. 18	0.371	0.225

Table 3: Spray Schedule and Infestation Counts - Elrod Orchard 1943

Plot	Cover 1/ Sprays	Materials 2/ (Amounts per 100 gallons)	Average Injury per 100 Fruits (all varieties): First Brood Worms	First Brood Stings	HARVEST Worms	HARVEST Stings	HARVEST Affected
I	1-3	1 pt. B.L. 40, 1 qt. S.B.O., 5# W.B.					
	4-5	8# M.B., 1 qt. oil, 1 pt. B.L. 40	.1	2.7	14.2	20.7	27.8
	6	8# M.B., 1 qt. S.B.O., 1 pt. B.L. 40					
	7	8# M.B., 1 qt. oil, 1 pt. B.L. 40					
II	1	1/4# S.B.F., 3# L.A.					
	2-3	4# L.A., 2 qt. oil, 1/2# Soap	.6	15.6	with lime 7.7	85.7	47.3
	4-5	3# L.A., 1# ZNSO4 2 qt. oil (1# lime on Row 1					
	6	1 pt. B.L. 40, 2 qt. oil, 1# M.B.			without lime 15.0	80.6	51.8
	7	2 qt. oil - 1/2# M.B.					
III	1, 5-9 11-13	3# B.L. 155	.4	6.0	5.9	24.5	21.5
	2-4	3# B.L. 155, 2 qt. oil					
	10	2# B.L. 155, 2 qt. S.B.O.					
IV	1-3	3# L.A., 2 qt. oil, 1/2# Soap	.5	5.5	17.3	44.8	32.0
	4-5 & top-off	5# W.B., 1# AlSO4 2 qt. S.B.O., 1# 13 oz.					
	6	1/2# M.B., 2 qt. oil					

1/ Entire orchard received -- April 13-22 Four sprays of liquid lime sulphur 1-60.
Calyx spray put on May 7-11 -- 3# Lead arsenate, 6# Wettable sulphur.

2/ L.A. -- Lead Arsenate
B.L. 155 -- Black Leaf 155
B.L. 40 -- Black Leaf 40
S.B.F. -- Soy Bean Flour
W.B. -- Wyoming Bentonite
M.B. -- Mississippi Bentonite (X 110)
$AlSO_4$ -- Aluminum Sulphate
$ZNSO_4$ -- Zinc Sulphate
Oil used was Gulf 302 or Shell Spuria 22.
S.B.O. -- Soybean oil

Table 4: Spray Schedule and Infestation Counts - Experimental Orchard 1943

			Average Injury per 100 Fruits (all varieties)				
	Cover Sprays after the first 1/	Materials 2/	First Brood		HARVEST		
Plot		(Amounts per 100 gallons)	Worms	Stings	Worms	Stings	Affected
I	2,3,4,5	9 1/2# Colloidal 77, 9# $AlSO_4$, 6# B.L. 155, 2 qt. S.B.O., 7 oz. Soap	1.6	5.6	7.0	20.2	19.9
	6	1 pt. B.L. 40, 1/4# M.B., 2 qt. oil on Winesap, 1 pt. Stop drop added to Delicious, No treatment on Grimes					
II	2,3,4,5	9 1/2# W.B., 9# $AlSO_4$, 2 qt. S.B.O., 2 2/3# Soap	1.6	7.3	4.5	11.6	13.0
	6	Same as Plot I					
III	2	3# B.L. 155	2.3	8.8	6.3	19.5	20.0
	3,4,5	9 1/2# Talcum, 9# $AlSO_4$, 6# B.L. 155, 2 qt. S.B.O. 7 oz. Soap					
	6	Same as Plot I					
IV	2	3# B.L. 155					
	3,4,5	9 1/2# Fuller's Earth 9# $AlSO_4$, 6# B.L. 155,	2.3	7.0	13.9	19.3	23.3
	6	1 pt. B.L. 40, 1/4# M.B., 2 qt. oil on Winesap, 1 pt. Stop drop on Delicious					
V	2,3,4	9 1/2# L.A. 9# AlSO , 6# B.L. 155, 2 qt. S.B.O., 7 oz. Soap	2.2	7.0	4.2	17.1	15.0
	5	Same as Plot I					

1/ Whole orchard received:
March 22-23 dormant spray; 6-5-100 Bx. with 2.5% Spuria 22.
April 10-24 four sprays of liquid lime sulphur 1-60.
May 3-6 Calyx spray; 3# Lead Arsenate, 3# lime, 6# Wettable sulphur.
First cover spray on all plots; 1/4 lb. colloidal 77; 3 lbs. Lead Arsenate; 1 qt. oil.

2/ $AlSO_4$ -- Aluminum sulphate
S.B.O. -- Soy Bean Oil
Oil -- Gulf 302 Spuria 15
W.B. -- Wyoming bentonite
B.L. 155 -- Black Leaf 155
B.L. 40 -- Black Leaf 40.

Table 5. Costs In Producing Apples Using The Four Spray Schedules Studied At The Elrod Orchard In 1943

Figures are based on actual production records from blocks of 50 mature trees producing an average of 15 bushels per tree, with an average price of $3.50 per bushel for U. S. No. 1's, $2.00 for those with one or more stings, and $1.00 for wormy fruit. Labor costs amounted to 35 cents per hour and spray materials were charged at prices quoted for lots such as would be used for a 200-tree orchard.

Schedule Used	No. Sprays	Plot No.	Cost of Materials	Cost of Application	Materials Plus Labor	Cost of Codling Moth Damage	Cost of Codling Moth Materials and Labor	Value of Crop Without Codling Moth Damage	Net Value	Net Per Bushel
			$	$	$	$	$	$	$	$
Tank-Mix Nicotine bentonite	7	1	111.69	48.61	160.30	418.72	579.02	2625.00	2045.97	2.72
Lead arsenate with Zinc sulphate and lime	7	2	57.53	48.61	106.14	590.36	696.50	2625.00	1928.50	2.57
Lead arsenate with Zinc sulphate and no lime	7	2A	57.26	48.61	105.87	595.13	701.00	2625.00	1924.00	2.57
Black Leaf at 7-day schedule	13	3	185.76	90.42	276.19	286.27	562.46	2625.00	2062.53	2.75
Lead-oil-soap 3 appl. Floc. Bentonite 3 appl. and a top-off with an ovicide late	6 plus a top-off	4	59.52	46.32	105.85	351.00	456.85	2625.00	2108.15	2.89

KANSAS

Ralph L. Parker and Paul G. Lamerson, Kansas Agricultural Experiment Station, Manhattan.

Zinc sulfate, in combination with lead arsenate and summer oil emulsion, was tested on Jonathan foliage during the season of 1943 for the fourth successive year as a safener or corrective for lead arsenate and as a control for codling moth. Summer oil emulsion was used in a series of tests from the second through the fifth cover sprays to determine the effect upon arsenic residue removal at the end of the season. Due to a possibility of a shortage of lead arsenate, two plots of nicotine--"Blackleaf 155"--plus summer oil emulsion combinations were included for comparison with the lead arsenate-zinc sulfate-oil emulsion combination spray as a control for codling moth.

Seasonal Conditions and Codling Moth Abundance

First Brood. The first codling moths of the overwintering generation were caught May 6 in bait traps. No catches were recorded in traps between May 6 and 21, due to abnormally cool temperatures accompanied by cold rains. Temperatures became more seasonable after May 21 and numerous larval entries were noted during the interval from June 7 to 12. No larval entries were noted previous to June 7. A steady hatch of larvae continued during the interval from June 14 to 19. More than 11 inches of rain fell during the interval from June 7 to 19, hindering spray operations. Due to frequent rains, many growers omitted or postponed second and third cover sprays. This delay resulted in poor control of first brood larvae, with resultant heavy second brood control difficulties. There was a pronounced decline in codling moth adult populations during the interval between June 25 and July 18. On July 18, codling moths obtained from an emergence cage and others caught in bait traps provided evidence that first brood moths were in flight. First brood moths responded to traps rather poorly during the first two weeks of their emergence. During this interval, the emergence cage was a more reliable index of activity than were the traps.

Second Brood. Ten days following emergence of first brood moths, fresh larval entries were observed. Warm temperatures and mild drought conditions during the interval from July 15 to September 3 furnished ideal conditions for the development of the codling moth. Largest catches of first brood moths were recorded August 13, 26 and 31. There was a large hatch of late larvae during the interval between August 25 and September 5. Cool weather following September 5 helped to retard damage by these larvae. Apparently, larval damage late in the season was by the progency of first brood moths.

Methods and Procedure

Two-tree replicates of the Jonathan variety were used for each dosage and material to be tested. The replicates were randomized throughout four rows of trees, with 10 trees to the row.

Wormy, stung and clean drops were collected from beneath each tree in each plot, and recorded throughout the season. Pre-harvest apple drops averaging 250 fruits per tree were recorded. During the 1943 season the characteristic pre-harvest Jonathan apple drop was not as severe as usual. Two hundred and fifty fruits per tree were recorded and were segregated into wormy, stung and clean apples at harvest time.

A fixed spray schedule in relation to the timing of the "Blackleaf 155" sprays, as recommended by the Tobacco By-Products and Chemical Corporation, was used for one plot. Spray timing for the divided schedule, using "Blackleaf 155" only for second brood control, was achieved by the use of bait traps and an emergence cage. The "Blackleaf 155" plot which was operated on a fixed spray schedule received, on July 9, an extra first brood spray. Due to a heavy hatch of late larvae, it was necessary, on September 3, to apply an extra spray to both nicotine plots.

The "Blackleaf 155" plot operating under the fixed schedule received a total of 10 cover sprays. The divided schedule nicotine plot operated under bait traps and emergence cage timing, received a total of 9 cover sprays. The lead arsenate plot and the lead arsenate-zinc sulfate-summer oil emulsion plots received during the season a total of 8 cover sprays.

Due to the tendency of the Jonathan variety to drop its fruit just before harvest, two hormone sprays of naphthalene acetic acid ("Niagara Stik", one of several commercial products) were applied on September 1 and September 9.

Materials and Dosages

The combinations of insecticides used in 1943 are indicated in table 1.

Table 1. Insecticides and dosages used in control tests in pounds per 100 gallons of spray mixture.

Treatment: (All treatments - calyx spray, lead arsenate, 4 lbs.)

1. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after second through eighth cover sprays.

2. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after third through eighth cover sprays.

3. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after fourth through eighth cover sprays.

4. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after fifth through eighth cover sprays.

5. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. Oil left out after third and zinc sulfate after fifth cover sprays.

6. Lead arsenate, 4 lbs.

7. Lead arsenate, 4 lbs. plus zinc sulfate, 4 oz. plus Superla oil emulsion, 1 qt. through first 4 cover sprays (first brood); "Blackleaf 155", 2 lbs. plus Superla oil, 2 qts. fifth through ninth cover sprays (second brood).

8. "Blackleaf 155" schedule of sprays.

   First cover, lead arsenate, 4 lbs.; second cover, lead arsenate, 3 lbs. plus B.L. 155, 1 1/2 lbs.; third cover, lead arsenate, 3 lbs. plus B.L. 155, 2 lbs. plus Superla oil, 2 qts.; fourth cover, B.L. 155, 2 lbs. plus Superla oil 2 qts.; fifth cover, B.L. 155, 2 lbs. plus Superla oil, 2 qts.; (beginning of second brood) sixth through ninth cover, B.L. 2 lbs. plus Superla oil, 2 qts.; tenth cover, B.L. 155, 3 lbs.

Information in regard to spray dates was determined by a series of 20 bait traps. One set of 10 traps was at the Blair experiment orchard, Blair, Kansas, and the other set at the Frank Lehman orchard, Wathena, Kansas. Daily codling moth catches and spray dates were furnished to the orchardists by the Doniphan County Farm Bureau, Troy, Kansas.

Spray dates for the 1943 season were as follows: Lead arsenate combinations: Calyx, May 3; first cover, May 21; second cover, June 3; third cover, June 14; fourth cover, June 22; fifth cover, July 20; sixth cover, July 30; seventh cover, August 11, and eighth cover, August 23. "Blackleaf 155" schedule: Calyx, May 3; first cover, May 21; second cover, June 3; third cover, June 11; fourth cover, June 22; fifth cover, July 9; sixth cover, July 20; seventh cover, July 30; eighth cover, August 11; ninth cover, August 23, and tenth cover, September 3.

At harvest time samples of apples from all lead arsenate plots were analyzed for arsenic residue.

Results

In recording the data on injured fruits, multiple stings or larvae in any one fruit were not considered. When a fruit had larvae and stings present, such a fruit was classified as "wormy".

The arsenical injury (spray burn) to foliage was determined by comparative observation of leaf color or injury and the retention of foliage at the end of the growing season. The trees in plot 6 sprayed with lead arsenate, without safener, showed the most severe arsenical injury to foliage. By September 1, approximately 60 percent of the foliage had been lost from the trees in this plot. Trees in plot 5 in which the zinc sulfate was omitted after the fifth cover spray also showed marked arsenical injury to foliage. Approximately 40 percent foliage loss was caused by the use of 3 non-corrective spray applications of lead arsenate. Trees in plots 1 to 4, in which zinc sulfate was used as a safener throughout the season, retained their foliage in good condition until harvest, September 20 and 21. There was little loss of foliage from the trees in these plots.

Trees in plots 7 and 8 sprayed with nicotine had relatively little injured foliage. In this respect, the foliage of trees in these plots was equal to or somewhat superior to that of the plots sprayed with the zinc sulfate-lead arsenate-summer oil emulsion sprays.

The application of two hormone sprays of "Niagara Stik" prevented the pre-harvest apple drop and made adequate coloring of fruit possible on the lead arsenate-zinc sulfate-summer oil emulsion plots. Applications of this hormone spray were made on September 1 and September 9. The fruit was still firmly attached to the twigs on September 20 when the apples were harvested.

In the badly defoliated lead arsenate, without safener, plot, there appeared to be a marked tendency of the trees to drop fruit early. Pre-harvest apple drop started August 31, when the two trees of this plot had more than 500 apples on the ground. By way of contrast, the lead arsenate-zinc sulfate-summer oil emulsion plots had only a few fruits on the ground on that date.

Data of the various insecticide tests for the control of codling moth in the Blair experiment orchard at Blair, Kansas, are recorded in table 2.

Table 2. Percentages of wormy and stung apples during various periods and the entire season, and residue analyses from lead arsenate spray plots.

Treat-ment	Apples dropped to August 22			Preharvest drops Aug. 31-Sept. 20			Harvest counts 1/		Summary (entire season)				Residue (grains As_2O_3 per pound)	
Number	Total per Plot	Per-cent Wormy	Per-cent Stung	Total per Plot	Per-cent Wormy	Per-cent Stung	Per-cent Wormy	Per-cent Stung	Total per Plot	Per-cent Wormy	Per-cent Stung	Per-cent Clean	Unwashed	Washed
1	152	21.7	9.2	444	27.9	33.6	9.0	51.0	1096	18.4	38.2	43.4	.128	.01
2	133	24.8	9.8	410	25.4	29.8	6.0	50.2	1043	16.0	37.0	47.0	.162	.007
3	102	9.8	7.8	374	15.8	38.8	14.0	45.8	976	14.2	39.2	46.6	.21	.007
4	125	12.8	8.8	390	17.4	25.4	5.6	35.2	1015	11.0	28.2	60.8	.118	.016
5	75	9.3	12.0	403	14.4	43.2	7.2	62.4	978	10.3	50.6	39.1	.217	.01
6	162	23.5	22.8	500	10.0	43.4	27.8	49.4	1162	19.5	43.1	37.4	.125	.008
7	107	33.6	5.6	397	37.2	14.4	16.8	25.8	1004	26.7	19.1	54.2	.187	.02
8	208	33.7	6.2	500	32.0	7.6	8.6	17.4	1208	22.6	11.4	66.0	No analysis	

1/ Residue analyses were made by Dr. B. L. Smits of the Department of Chemistry, Kansas State College.

Discussion

The objects of the tests for the season of 1943 were to observe the effectiveness of the materials tested in codling moth control, to observe spray injury to foliage, and to determine the effectiveness of nicotine sprays because of a possibility of a future shortage of lead arsenate.

The set of fruit at the Blair experiment orchard was light and unevenly distributed. At the time of bloom, a frost during the first week in May reduced the set of fruit to one-fourth normal, with the resultant effect of a high concentration of larvae in the remaining apples. The severity of the attack on the apples also was increased by the poor timing and omission of several cover sprays to the trees adjacent to the experiment plots. The infestation of codling moth was large, since there had been a medium to large apple crop in 1942. The 1943 yield ranged from 3 1/2 to 14 "field boxes" 1/ per tree. Since the treatment and yield of trees within the same plot varied widely, the control percentages varied considerably with tree records with the same dosage of insecticide. In general, the trees of any given plot showing the smallest yield also had the severest injury to fruit by codling moth. Heavy rains during June hindered and delayed the timely application of cover sprays, which further complicated the codling moth control problem. Delays in first brood sprays resulted in poor control, a heavy second brood, and a large percentage of stung fruit at the close of the season.

Arsenic tolerance of 0.025 grain of arsenic per pound of apples, is allowed by the Federal Security Agency. The use of oil in the fourth and fifth cover sprays increases the difficulty of removing the arsenic from the harvested apples by the standard acid wash (table 2).

Summary

The comparisons of injured and non-injured apples are given in table 2, which is a summary accounting for all apples dropped or harvested.

The trees in plot 8 sprayed with "Blackleaf 155" and summer oil emulsion under the fixed spray schedule gave the most effective control as expressed as clean fruit per plot. This plot had next to the highest percent of wormy apples in the 8 insecticide combination tested. Ten cover sprays were applied to this plot during the season.

1/ A "field box" contains 1 1/4 bushels of apples.

The trees in plot 4 sprayed with 8 cover sprays of lead arsenate-zinc sulfate-summer oil (oil in 5 cover sprays) gave the second best control in clean fruit per plot. This plot had next to the lowest percent of wormy apples in the 8 insecticide combinations tested.

The trees in plot 7 sprayed with lead arsenate and zinc sulfate to control the first brood larvae, and with "Blackleaf 155" and oil for second brood larvae control (biological spray timing), ranked third in clean fruit. This plot had the highest percent of wormy apples in any of the insecticide combinations tested.

The trees in plot 6 sprayed with lead arsenate, without safener, produced the lowest percent of clean fruit in all the 8 insecticide combinations tested. The trees in this plot showed 60 percent arsenical injury to foliage with subsequent defoliation.

The trees in plot 5 sprayed with zinc sulfate, which was omitted after the fifth cover spray, had 40 percent foliage loss.

The trees sprayed with zinc sulfate as a safener throughout the season had excellent foliage at harvest time.

The trees in the nicotine plots had excellent foliage at the end of the spray season. The trees in these plots had the fewest stung apples per plot but they also produced the greatest percent of wormy apples per plot.The gain secured in fewer stung fruits could be accounted for by the toxic action upon the young larvae of the nicotine and the extra cover sprays applied to these plots.

The application of two hormone sprays of naphthalene acetic acid--"Niagara Stik"--effectively held the apples on the trees until they gained adequate color and were harvested September 20 and 21. During the season of 1942, the trees in the zinc sulfate-oil emulsion plots dropped their fruit during the preharvest drop before adequate color was obtained. The use of hormone sprays overcame this difficulty in 1943. The tendency toward a heavy preharvest drop, however, was less marked in 1943 than in 1942.

The color of the fruit on the trees in the nicotine plots appeared to be somewhat dulled at harvest as compared to that of some of the lead arsenate combination plots. This dullness disappeared after the fruit was put through a fruit washer. Then the apples appeared as glossy and bright as any sprayed with lead arsenate.

The control of codling moth in the spray test plots in 1943--a light fruit crop year--was only about one third as effective in relation to stung, wormy and clean fruit as was the control obtained in the test plots in 1942.

In general, the trees in the plots in which lead arsenate-zinc sulfate-summer oil emulsion was used had fewer wormy and many more stung apples than those in the nicotine plots.

The percentage of control obtained in 1943 was poor but, in marketable fruit, the control was fair. Many of the fruits recorded as stung had small, well healed stings, so small as scarcely to affect the salability of the fruit.

Due to frequent and heavy rains during the spring and early summer, the most effective control of codling moth in the plots treated with lead arsenate-zinc sulfate-summer oil emulsion occurred in the plots which received the most oil sprays during the season.

All samples of harvest apples, when analyzed for arsenical residue, had more than the tolerance of 0.025 grain of arsenic per pound of fruit. The acid wash reduced all of the residues to below tolerance.

KENTUCKY

W. A. Price, Kentucky Agricultural Experiment Station, Lexington

There was an unusually small carryover of codling moth worms from 1942 but 1943 conditions were favorable for codling moth development. At Paducah, moths from overwintering worms began emerging April 28 and continued to do so into early June. First generation moths began emerging June 29 and continued emerging through July. During August and early September, in some orchards, there was a heavy emergence of second generation moths. At Lexington, moths from overwintering worms began emerging May 16 and continued to do so through the second week of June. Emergence of first generation moths began July 14.

No detailed control experiments were conducted. At the Lexington Station orchard an intensive lead arsenate-weak bordeaux spray program resulted in an unusually clean crop. In the young orchard, Red Delicious had 92.6% clean fruit, 5.7% stung and 1.7% wormy. Staymans had 93.9% clean fruit, 2.9% stung and 3.2% wormy. Winesaps had 98% clean, 1.7% stung and 0.42% wormy. In the old orchard Red Delicious had 54% clean, 18% stung and 28% wormy.

Several Western Kentucky growers who were unable to obtain control of codling moth with lead arsenate spray programs, produced fine crops of clean fruit using nicotine bentonite.

MASSACHUSETTS

A. I. Bourne, Massachusetts Agricultural Experiment Station, Amherst.

I. In eastern Massachusetts there apparently was a slight increase in both the prevalence of moths and in the amount of damage from codling moth, but on the whole the damage was not particularly serious. I think that in the western part of the state there was somewhat heavier infestation, and in some particular orchards there was a decided increase in the amount of damage over the last two or three seasons.

III. A.

(1) Lead arsenate. In cooperation with the Departments of Pomology and Plant Pathology we ran orchard tests of various insecticides for control of orchard pests including codling moth, and since we were also studying effects of various combinations on apple scab our results are based on the yield records of McIntosh at harvest, that variety being very susceptible to apple scab and is the predominant commercial variety in the State.

In the plots receiving the standard schedule which is recommended for general conditions in Massachusetts there was 23 percent codling moth and 5 percent apple scab as compared with 72 percent codling moth and 96 percent scab on unsprayed checks. This was a considerable increase in the amount of codling moth damage over 1942 and the percentage of increase was proportionally the same in the treated and in the check plots.

(4) a. Fixed nicotine. A special application of fixed nicotine (Black Leaf 155) in an application midway between our second and third cover sprays reduced codling moth damage to 13 percent, 10 percent lower than was secured from the regular standard schedule containing lead arsenate.

One application of a fixed nicotine spray (Black Leaf 155) replacing lead arsenate in the fourth cover spray reduced codling moth damage to 7 percent, and when this was followed by an additional application of fixed nicotine applied about mid-August, injury was cut to 5 percent, a reduction of 78 percent from that secured by the standard schedule and 92 percent reduction in the amount of damage from unsprayed checks.

(4) d. Nicotine in a base of glyceride oils (DX nicotine) in a modified schedule which called for reduced strengths of lead arsenate in the cover sprays held codling moth damage to 5 percent, a 78 percent reduction from the standard schedule, and with approximately the same protection against apple scab, and giving a protection to the fruit equivalent to two applications of fixed nicotine mentioned above.

IV. From the evidence furnished by representatives of the leading insecticide companies operating in Massachusetts and from reports by the growers, sufficient supply of insecticides was available for the needs of the growers in the State. There may have been some exceptions to this but they were not brought to our attention. I mention this latter item because of the remarks made by insecticide salesmen. The larger, standard companies which have been operating in the State for many years made every effort to see that the needs of their regular customers were supplied, and, so far as I have been able to discover, adequate supplies were made available. In this State, as I presume in many others, there are a certain number of what the trade refers to as "wildcat" buyers who have been in the habit of shopping about from company to company before placing their order, trying to get one company to bid against the other and seldom, if ever, placing their entire order with one company or at least seldom doing so more than two years in succession. These men in some cases had difficulty in getting their supplies or, in other words, they were taken care of after the needs of the regular customers were satisfied but, even so, I do not know of any instances where the control program was seriously interfered with because of lack of materials.

In regard to spray equipment there was very little new material available, and this was allocated, so far as possible to fit the most pressing needs. For the most part the growers had to patch up and recondition the equipment which they already had. When we consider the transportation limitations and other difficulties incidental to the war emergency, the growers owe a great deal to the various companies who handle spray materials and spray equipment for their very sincere and strenuous efforts to see that the needs of the fruit industry are supplied.

MISSOURI

Lee Jenkins, Missouri Agricultural Experiment Station, Columbia

I. Seasonal conditions and status of codling moth infestations during 1943.

The codling moth population carrying over winter was fairly high in the University orchard near Columbia, where the major part of the spray plat work was done. The season was favorable for codling moth control during the first brood. The first moths were about a week later coming out than usual, and frequent rains during May and June held worm populations to a low point during the first brood. Weather conditions during July and August were favorable for codling moth development and the major portion of the damage was done to the fruit during this period.

II. Studies on codling moth biology or behavior.

No biological studies were carried on in 1943, except for the bait trap records kept each season in five areas of the state.

III. Results of control experiments.

Experimental set-up. The major part of the experimental work in 1943 was done in the University orchards near Columbia, in cooperation with H. G. Swartwout of the Horticulture Department, who prepared the report on spray injury to foliage and fruit included in this paper. Jonathan and Golden Delicious were used in the tests. The Jonathan trees were not very uniform with regard to size and crop. The Golden Delicious were fairly uniform in size of trees and amount of crop.

Additional cooperative spray plats were located at the State Fruit Experiment Station at Mountain Grove, in cooperation with Director Paul H. Shepard. The Champion trees used in these experiments were fairly uniform in size, but varied considerably in amount of crop.

Injury to foliage or fruit (at Columbia). Lead arsenate was used at 3-100 except in the third and fourth covers, when owing to heavy rains and a large codling moth population in the experimental orchard the dosage was increased to 4-100. The trees were thoroughly covered, using more material than is applied by the general run of growers, but the amount would not be considered as excessive. Rains and heavy dews in the spring and early summer were unusually favorable to arsenical injury.

Lead arsenate without a corrective caused nearly complete defoliation of Jonathan by midsummer. By late summer injury to Golden Delicious leaves was severe and the trees did not mature the fruit properly.

Lead arsenate with 1-1-100 zinc and 1/2-1-100 Bordeaux as safeners almost eliminated arsenical injury to the foliage of Golden Delicious throughout the season and held injury to Jonathan leaves to no more than a trace until near the end of the season when light injury appeared, but it was markedly less than with lead arsenate alone. Neither of the safeners beginning in the second cover increased fruit russeting, nor did they decrease russeting. Little russeting was evident on Golden Delicious fruit this year, but sprayed Jonathan fruit was much russeted, apparently due to calyx and first cover applications of lead arsenate since the fruit on unsprayed Jonathan treec was nearly free of russet.

A copper arsenate, 3-100 with 1-1-100 zinc-lime safener, beginning with the second brood sprays, caused practically no leaf or fruit injury on Jonathan and Golden Delicious. It was not used this year without a safener, as experience in the two preceding years indicate that without a safener severe foliage burning could be expected.

A fixed nicotine, Black Leaf 155 at 3-100, without oil beginning in the second cover caused no detectable ill effects. The foliage and fruit were especially bright and glossy.

Where 1/2 gallon of a summer oil in 100 was added to Black Leaf 155 at 2-100 beginning in the second cover, the surface of the fruit was dulled and the leaves had a dull oily appearance. The fruit of Golden Delicious was decidedly unattractive, although the flavor and eating quality did not seem to be affected.

Where Black Leaf 155 with oil was used beginning in the second brood, an oily appearance to the foliage and fruit could be detected, but the dulling of the fruit surface was much less pronounced than where applications were begun in the second cover.

A. Control by insecticides.

The data included in this report is from plats in the University orchard at Columbia, and from plats in the State Fruit Experiment Station orchard at Mountain Grove.

The following arsenical materials were used on the Golden Delicious plats at Columbia (dosages are for 100 gallons): (1) Lead arsenate alone, (2) lead arsenate and Safe-N-Lead, (3) lead arsenate and bordeaux, (4) lead arsenate and zinc bordeaux, and (5) lead arsenate in first brood, followed by four covers of

copper arsenate plus 1-1-100 zinc-lime. All lead arsenate cover sprays included 3 pounds, except the third and fourth covers which included 4 pounds. Eight covers of lead arsenate were used, the last one applied on August 2.

The following combined lead arsenate and nicotine plats were also included in the experiments: (1) Black Leaf 155, 3 pounds, without oil, (2) Black Leaf 155, 2 pounds, plus 1/2 gallon oil, (3) Black Leaf 155, 2 pounds, plus 1/2 gallon oil beginning with the second brood, and (4) Nico-sol, 3 quarts, plus bentonite, 1 pound, in fifth cover, and Nico-sol, 2 quarts, plus bentonite, 1 pound, in sixth seventh, eighth and ninth cover sprays. The full season's schedule of Black Leaf 155 included 3 pounds lead arsenate in the first cover and eight covers of Black Leaf 155 and oil, the last spray being applied on August 23. The Black Leaf 155 and oil beginning in the second brood had four first brood sprays of lead arsenate and five Black Leaf 155 and oil sprays on the same schedule as where eight covers of Black Leaf 155 were used. The Nico-sol and bentonite applications started with the second brood, following four lead arsenate sprays for the first brood.

The following table gives the results secured on Golden Delicious:

Treatment	No. Trees	% Wormy	% Stung	% Clean
Lead alone	2	12.5	21.5	65.9
Lead Arsenate with Safe-N-Lead (beginning 3rd cover)	2	16.3	22.7	60.9
Lead Arsenate + 1/2-1-100 Bordeaux (beginning 2nd cover)	1	33.4	34.9	31.7
Lead Arsenate with 1-2-100 Bordeaux added, beginning 2nd cover	1	35.1	25.2	39.7
Lead Arsenate + 1-1-100 Zinc-lime (beginning 2nd cover)	2	17.5	31.1	51.1
Lead Arsenate with 2-2-100 Zinc Bordeaux, beginning 2nd cover	1	27.2	28.8	44.0
Copper Arsenate + 1-1-100 Zinc-lime, beginning 5th cover	2	59.3	16.8	33.9
Black Leaf 155 alone 3-100, beginning 2nd cover	1	21.4	17.9	60.6
Black Leaf 155 and Oil, beginning 2nd cover	1	14.2	7.1	78.7
Black Leaf 155 and Oil, beginning in 2nd brood	4	15.8	16.1	68.
Nico-sol and Bentonite, beginning in 2nd brood	2	18.9	18.1	63.

These results on Golden Delicious and in the Jonathan blocks, at Columbia, showed a trend toward more clean fruit where nicotine and oil were used, beginning with the second cover or with the second brood sprays, than where lead arsenate was used alone. There also was a trend toward poorer control where safeners were added to the lead arsenate.

At Mountain Grove, there appeared to be a slight decrease in control where a safener was added to the lead arsenate. The nicotine plat gave less control than the lead arsenate, probably due to omission of oil in the fifth cover.

At Mountain Grove, three plats were sprayed with the following materials: (1) Eight covers of lead arsenate, 3 pounds, (2) Same as (1) plus 1-1-100 zinc-lime beginning with second cover, (3) lead arsenate and Black Leaf 155. Same as (2) for first three covers, and 2 pounds Black Leaf 155 plus 1/2 gallon oil in fourth, 2 pounds B.L. 155 in fifth, and 1 1/2 pounds B.L. 155 plus 1/2 gallon oil in sixth, seventh and eighth. All plats were sprayed on the same schedule.

The following table gives the results secured in the experimental plats at Mountain Grove on Champion apples:

Treatment	No. Trees	% Wormy	% Stung	% Clean
Lead Arsenate alone	4	39.3	20.7	40.3
Lead Arsenate plus Zinc-lime 1-1-100	4	46.5	17.4	36.3
Lead Arsenate plus Black Leaf 155	4	57.6	13.7	28.6

Materials for use against mature larvae or pupae in cocoons. The codling moth spray for dormant application developed by Yothers at Yakima was applied to Winesap tree trunks on April 3, 1943, to see what effect it would have on overwintering larvae on tree trunks in Missouri. The formula used was the 4,6-dinitro-ortho-cresol .5%, sodium lauryl sulfate .5%, and 1.5% of each of the following penetrants: Ethylene glycol mono butyl ether and trichloroethylene. Tests were also made using the same formula without the penetrants.

An application was made on Bendavis trees, using a spray composed of Elgetol, 1 quart, plus 1/2 gallon fuel oil and 4 ounces sodium lauryl sulfate, and water to make 5 gallons.

In all applications the tree trunks were thoroughly soaked with the spray, using a bordeaux nozzle with a pressure of between 150 and 200 pounds. None of the applications gave any kill of codling moth larvae.

IV. There was no serious difficulty experienced by growers in obtaining spray materials. Repairs and equipment were more difficult to obtain, but growers were able to maintain their equipment reasonably well.

NEW JERSEY

B. F. Driggers, New Jersey Agricultural Experiment Station, New Brunswick.

I. Seasonal conditions and Status of Codling Moth Infestations during 1943.

The beginning and peak of adult codling moth emergence during 1943 in New Jersey was about normal. First egg hatching of first brood was observed in the Glassboro district on May 20, causing the second or 14-day-after-petal-fall spray to be an important codling moth cover spray. May and June were fairly wet and cool which favored codling moth control except that in some low lying areas of orchards soft ground prevented spraying at the proper time.

The last half of July, August and September were dry, bordering on drought conditions in many orchards. Under these conditions second brood and a partial third brood of worms caused considerable damage in some orchards. Complicating and adding to the codling moth damage was the fact that in many orchards of central and southern New Jersey the apple crop was light, particularly on fall and winter varieties.

II. Studies on Codling Moth Biology or Behavior.

No specific work was engaged in along this line. Cages and bait pans were used and recommended to time codling moth emergence. Bait pans, using molasses and water 1-10 plus yeast were generally used. The beginning and peak of overwintering codling moth emergence was timed well with bait pans. However, this bait was not very effective in timing second brood worm attack. Relatively few moths were attracted to the bait pans in July and August.

III. Results of Control Experiments.

A. Control by insecticides.

Field spraying experiments for codling moth control in 1943 were limited to experiments designed to compare the effect of (1) adding 1/2 pint of nicotine sulfate to each cover spray of an oil-lead arsenate spray and (2) adding 1 pint of nicotine sulfate in two cover sprays at the peak of first brood and in one cover spray at the peak of second brood.

A fifteen row block of Rome trees was divided into three plots of five rows each. All three plots received the special spray schedule recommended for orchards in southern New Jersey where codling moth is a serious problem. This consists of lead arsenate in the calyx, followed by lead arsenate plus fungicide 7 and 14 days after calyx, followed by oil-lead arsenate-bordeaux 21 and 31 days after calyx, followed by a fifth cover spray of lead arsenate-bordeaux 41 days after the calyx spray. Three second brood sprays are recommended using lead arsenate-weak bordeaux with summer oil at ovicidal strength in the second of these three sprays.

The first of the three plots was sprayed as above outlined plus 1/2 pint of nicotine sulfate to 100 gallons in each of the 8 cover sprays. Plot 2 was sprayed with the basic schedule plus nicotine sulfate 1 pint to 100 gallons in the 2nd, 3rd and 7th cover sprays. Plot 3 received only the basic schedule of oil-lead arsenate and served as a check plot for plots 1 and 2.

To determine relative codling moth control in the three plots, six trees, uniform in size and crop, were selected in each plot. The wormy drops under these 18 trees were recorded weekly from July 1 to September 15. The results are summarized in table 1.

Table 1. Summary of results of control experiments:

Plot	Wormy Dropped Apples 6 Trees			Wormy Dropped Apples per Tree		
No.	1st Brood	2nd Brood	Both Broods	1st Brood	2nd Brood	Both Broods
1	85	619	704	14.3	103	117
2	114	1459	1573	19.0	243	262
3	426	1897	2323	71.0	316	387

IV. Experience of Growers in Obtaining Insecticides and Spray Equipment during 1943.

No particular difficulty was encountered in obtaining sufficient of the basic spray materials such as lead arsenate, oil, lime, nicotine and copper. Spray equipment, particularly parts and service, was difficult to secure. The number of so-called "Speed Sprayers" in the state was doubled over the number in operation in 1942. Growers generally reported satisfactory results with them particularly from the labor savings angle. A few growers took too literally the "Speed" part of the name and tried to cover too much acreage with one machine. Results were not satisfactory as might be expected.

NEW YORK

S. W. Harman, New York State Agricultural Experiment Station, Geneva.

The winter of 1942-43 experienced three sub-zero periods which probably accounted for a higher overwintering mortality of codling moth caterpillars than normal. However, a favorable season following developed into one of the more difficult years in which to control this insect.

Control by Insecticides, Experimental.

Organic insecticides were used to control the codling moth in the second brood sprays, following first brood treatments with lead arsenate. The materials mentioned are in order of their efficiency, the most efficient heading the list. Lead arsenate is included for the purpose of comparison.

1. Phenothiazine - 3 1/4 pounds in 100 gallons. This was a micronized and conditioned material supplied by du Pont. It left considerable residue.

2. Pratt's DX-nicotine - 1 1/2 pints, lead arsenate - 2 pounds. Residue analyses at harvest = As_2O_3 - 0.134 grain, Pb - 0.301 grain.

3. Lead arsenate - 3 pounds. Residue: As_2O_3 - 0.097, Pb - 0.230.

4. Genicide - 2 pounds, kerosene - 3 pints.

5. Black Leaf 40 - 1 pint, summer oil - 2 quarts.

6. Black Leaf 155 - 3 pounds, summer oil - 2 quarts.

Control by Means Other Than Spraying

As a result of the war-time shortage in labor that now confronts our fruit growers, considerable interest has developed in orchard dusting. A major project was started this past season in the several different fruit sections of the state to determine the value of the most promising dusts when used against the codling moth. This report concerns tests made near Geneva, New York.

A mature McIntosh orchard well populated with the codling moth was selected. Six cover sprays were applied between June 21 and August 23. A similar program of dust treatments was also used with the exception that one extra dusting was made on August 30. From 2 to 2 1/2 pounds of dust was applied to trees that took approximately 15 gallons of spray. The dusting was done in the evening just before dark, taking advantage of the quiet conditions and the presence of dew on the trees.

Three dust formulae were used, namely:

60-20-20 dust contained	60 pounds microsul dusting sulfur
	20 pounds lead arsenate-
	20 pounds Black Leaf 155
75-15-10 dust contained	75 pounds microsul dusting sulfur
	15 pounds lead arsenate
	10 pounds Black Leaf 155
80-20 dust contained	80 pounds microsul dusting sulfur
	20 pounds lead arsenate

The following data will serve to indicate the results of the first season's tests.

Comparison of Dust and Spray Programs for Combating the Codling Moth, 1943

(Based on the total crop including both dropped and picked fruit.)

Treatment	Number of fruits counted	Deep worm holes per 100 apples	Stings per 100 apples	Percent fruit free of codling moth injury
Spray: Sulfur-lead arsenate	8405	9.0	22.7	79.1
Dust:				
Sulfur-lead arsenate-nicotine 60-20-20	10622	9.4	10.3	87.4
Sulfur-lead arsenate-nicotine 75-15-10	6600	10.2	10.9	83.5
Sulfur-lead arsenate 80-20	6025	24.7	27.6	67.1
Checks - untreated	9302	90.1	11.7	25.6

The dusting operation proved to be approximately four times faster than spraying. On the other hand, considering the cost of labor, operation of machinery, and materials, the cost of one application of the 75-15-10 dust was nearly twice that of one spray treatment.

It is planned to continue this project during 1944.

OHIO

C. R. Cutright, Ohio Agricultural Experiment Station, Wooster

I. Seasonal conditions and codling moth abundance.

A cold, late spring, with temperatures 5° F. below normal in April and slightly below normal in May, delayed codling moth emergence (see following table). However, on May 29 warm weather started and continued, with temperatures over 5 degrees above normal for June. July and August were also above normal, with September decidedly cooler than average.

The sudden high temperatures of the last few days of May and early June resulted in high peaks of emergence and egglaying occurring in most sections of the State from June 1 to June 5. So great was the influence of the high temperatures of June that first-brood injury was above normal and the first larvae were taken under bands at about normal dates. Second-brood injury was not as severe as usual but due to the unusual amount of first-brood attack on a short crop, codling moth was again a serious pest. Even in northeastern Ohio, a few orchards had serious codling moth injury.

Summary of Codling Moth Biology, Ohio, 1943

	Wooster (N. E., Central)	Waterville (N.W.)	Lorain (North)
	Spring-brood Emergence		
First moth	May 23	May 22	May 31
50%	May 31	June 1	June 15
Last moth	June 23	June 30	July 5
	Summer-brood Moth Emergence		
First moth	July 13	July 15	July 20
50%	Aug. 4	Aug. 5	Aug. 1
Last moth	Sept. 2	Sept. 5	Aug. 31
	First-brood Larvae under Bands		
First larva	June 25	June 28	July 2
Peak	July 14	July 19	July 23

II. Studies on codling moth biology or behavior.

Observations made during a 3-year period in two northern Ohio orchards indicate that considerable difference may exist in the biology of the moth in the two locations, this despite the fact that climatic differences are small. In the 3-year observations at Lorain, Ohio, the first moth of the overwintering generation appears approximately one week later than at Waterville and peaks of emergence are correspondingly delayed. The evidence indicates that this variable is inherent in the strain of codling moth in this particular orchard, rather than its being due to seasonal ecologic factors. Further work to determine this point is in progress.

III. (a) The experimental work of 1942 was conducted in the Frank Farnsworth orchards at Waterville, Ohio, and in the H. W. Schmitkons orchard at Lorain, Ohio. Mature trees of the variety Jonathan were used in both cases, with single-tree plots replicated 5 times for each treatment or schedule.

(b) Due to a very poor season for pollinization, the trees did not produce as heavy or as uniform crop as could be desired. It is thought that this condition caused some of the confused data that came from some of the plots.

(c) There were no significant cases of injury to foliage or fruits by the experimental spray schedules. Tests for the prevention of foliage injury included the addition to lead arsenate of lime and zinc sulfate, of DN-111, and of Fermate. All three schedules, including the foregoing materials, produced satisfactory foliage. Six cover sprays were used in each schedule. The interesting fact was clearly established that such diverse materials as DN-111 and Fermate used alone with lead arsenate in numerous applications (6) would prevent injury of a serious nature on the variety Jonathan.

(d) The heaviest visible residue was obtained where lead arsenate-summer oil and Fermate were used in combination in three first-brood covers. The residue was reduced (visibly) when a spreader was added to the foregoing combination (residue analysis not yet available).

A. Control by insecticides.

During the season of 1943, 28 spray schedules were tested in the two experimental orchards. Within each experiment, different schedules may be grouped because of certain similarities. The data within each group have been summarized and are presented in the following table.

Waterville Data - 1943

Type of schedule	% of fruit wormy	% of fruit stung	% of crop injured by codling moth
Lead arsenate 3# (means of 6 lead schedules)	18.4	64.3	69.1
Lead-oil 1/ (means of 4 schedules)	16.2	59.0	63.6
Lead-B.L. 155 2/ (means of 3 schedules)	16.6	56.0	62.3
Lead-oil-B.L. 155 3/ (means of 2 schedules)	11.9	60.3	64.0
Oil-B.L. 155 4/ (means of 5 schedules)	18.3	38.8	49.9
Lead-dinitro 5/ (means of 2 schedules)	20.4	60.9	66.4

1/ Summer oil at 3/4 % in second, third, and fourth covers.

2/ B.L. 155, 1 1/2 pounds per 100 gallons in second, third, and fourth covers.

3/ Summer oil and B.L. 155 as used in 1 and 2 combined. A small amount of lime used with this combination undoubtedly reduced the effectiveness of the nicotine.

4/ Oil at 1/2% and B.L. 155, starting in the third cover, 5 applications. B.L. 155 1 1/2 pounds in the third cover, 2 pounds in other sprays.

5/ Dinitro at 1 pound and 5/8 pound per 100, starting in the second cover, and used with lead alone in 6 applications.

The foregoing table summarizes the results obtained in a difficult season, complicated by a short crop and hail injury.

The differences between schedules within groups were mostly due to different fungicides or spreader-stickers. Under the conditions of the season, no schedule or group of schedules was particularly effective. Significant differences do not exist except for the control of stings obtained by oil-nicotine and the control of worms by lead-oil-nicotine.

The data from plots at Lorain is not included since results are almost identical with those at Waterville.

(1) Lead arsenate used alone was not satisfactory; nor were results much better when used with stickers (Alkote) or with dinitro. In fact, dinitro in numerous applications may have decreased its effectiveness, though no significant difference can be shown. Dinitro used at one pound per 100 produced better foliage than did 5/8 pound, but the lesser dosage seemed better in worm control.

The lead-oil schedules were not as efficient as in some former seasons.

(2 & 3) There was no work with non-lead arsenicals or cryolite.

(4) A schedule of lead arsenate plus B.L. 155 used with the sticker Alkote gave good results. Oil plus B.L. 155 has been mentioned as outstanding in the control of stings. No other organics were used.

B. Spraying is practically the only method of codling moth control in Ohio. Possibly due to labor shortage, but more likely due to ineffectiveness in growers' hands, scraping and banding have practically disappeared.

IV. Ohio growers had little difficulty in obtaining insecticides and spray equipment in 1943. Some delays were caused by slow delivery of spare parts.

OREGON

Leroy Childs and R. H. Robinson, Hood River Branch Experiment Station, Hood River.

Introduction:

Codling moth investigations were continued during the year 1943. Various phases of which are discussed in the following report: See earlier summaries.

Seasonal Conditions:

As far as we were able to determine, winter weather conditions were not sufficiently severe to cause destruction of over-wintering codling moth larva in the lower Hood River Valley. A minimum of -4 was recorded at the Experiment Station although in the higher elevations of the Valley, as low as -16 occurred, accompanied by considerable tree damage. No observations were made relative to larval mortality where the lowest temperatures occurred. A number of growers experienced more than usual first brood damage. From these observations it can be assumed the carry-over was not materially reduced by winter conditions.

Character of Tests and Expected Variation:

From many years' experience at the Station, it is known that certain areas in the orchard are consistently more wormy than others. Alternate production of the Newtown apple oftentimes makes it difficult to arrange a series of tests that will conform to standard procedure. In 1943, four replicated tests were conducted and located in three different parts of a 12-acre block where rather regular codling moth damage had occurred in the past. The plots in these areas were sprayed in double rows from North to South. The three areas were, therefore, 8 rows across beginning with plot 1 on the West side of the area sprayed; the procedure was regular to plot 4 on the East. Stationery equipment was employed in these tests, 1000 gallons of spray being applied in each of the four experiments. The same men were employed in the different areas throughout the season. Four of the single plot tests (applied for scab and codling moth control) were sprayed with portable equipment in an area where codling moth damage has been relatively uniform in the past. Two hundred gallons per plot were used in these tests and sprayed in 2-row units. The arrangements of the plots beginning on the South and proceeding North, was as follows: Exps. 4, 3, 1 and 2 (See table for results) Exps. 5 and 6 checked primarily for scab control and tar oil injury, were located in a portion of the orchard where codling moth damage has been consistently lower than in other parts of the orchard.

Recorded injury was taken from picked fruit only. No check-up was made of first brood drop; late drop was of no particular consequence. All questionable stings were opened; all injuries called stings unless worms penetrated to a depth of more than 1/4 inch. All injuries were recorded. Results were determined on percentage of "clean", "wormy" and "stung" fruit.

The moth catch at the Station (a 15-year record involving 10 traps examined every other day throughout the season) was 64% greater than obtained in 1942, the latter being the smallest catch taken since

1935. The first moths were taken at the Station on May 16 as compared to May 6th in 1942, April 27th in 1941, May 4th in 1940 and April 27th in 1939. The earliest moth catch record obtained during this 15-year period, was recorded on April 14, 1934. With the exception of a week (April 11th to 18th) of abnormally high daily temperatures, three days of which were in the eighties, spring weather prior to moth emergence, was subnormal, accompanied by generally low daily temperature and more than average rainfall.

1943 Tests:

Four replicated tests were conducted in the Station orchard for codling moth alone, together with a number of single plot tests involving the control of apple scab and codling moth. In view of the fact Phenothiazine (1/2 lb. - 100, plus lead arsenate, 2-100 used with soy bean flour 1/3 lb. - 100) produced outstanding control in 1942, particularly in the form of "sting" reduction, this material was used again in 1943.

Table 1. Summary of Codling Moth Control, Newtown Variety - Replicated Plots.

Exp. No.	Material and Program 1/	% Wormy	% Stung	% Clean	% Scab	Spray Injury
S-1	Lead Ars. 2-100: Phenothiazine 1/2-100 Soy Bean Floar 1/3-100, 5 covers	2.4	9.8	88.4	5.3	.0
S-2	Kryocide 2-100; Phenothiazine 1/2-100 Soy Bean Flour 1/3-100, 5 covers.	1.9	9.6	88.8	4.8	.0
S-3	Lead Ars. 3-100 plus 3/4-100 Shell light; 1 - 2 - 3 covers; lead ars. 3-100 plus Fluxit 1/4-100, 4th and 5th.	1.4	12.5	86.4	5.2	.0
S-4	Lead Ars. 3-100 plus Fluxit 1/4-100, Calyx and 5 covers.	2.3	17.4	81.04	6.0	.0

1/ Calyx spray same in all tests. Ars. Lead 3-100 plus 1/4 - 100 Fluxit.

Table 1. (Continued)

Single Plot Tests

Exp. No.	Material and Program	% Wormy	% Stung	% Clean	% Scab	Spray Injury
1	Lead Arsenate 3-100; Fluxit 1/4-100 Calyx and 5 covers. Bordo Mix. 1-1-100 added Calyx 1, 2, 3.	6.0	27.0	69.2	1.3	23.6 2/
2	Same as above, using Copper Phos. 4-4-4-100 in calyx, 1, 2, 3.	5.6	24.0	73.0	2.6	.0
3	Calyx as Exp. 2; Lead arsenate as Exp. 1 throughout; Fermate 2# - 100, 1st, 2nd and 3rd Cov. plus Shell Lt. 1% 1/	1.6	15.2	83.9	8.2	.0
4	Calyx as Exp. 1, 5 covers Rustica Tob. 3 1/2# - 100 plus Bentonite 1/2-100 plus Alum. Sul. 2 oz.-100 plus Shell light 1% in 1 and 2; Bal. 1 qt. - 100	23.0	20.1	64.0	7.5	.0
5	Tar oil 1% when 10% of bloom open. Bal. as in Exp. 1	-	-	-	.8	14.0 3/
6	Tar oil 2% when 10% of bloom open. Bal. as in Experiment 1.	-	-	-	.6	22.3 4/

1/ Calyx spray same in all tests. Ars. Lead 3-100 plus 1/4 - 100 Fluxit.

2/ Injury (russet) classified as 17.6 slight; 6.0 medium; 0 severe.

3/ Injury (russet) classified as 10.9 slight; 2.7 medium; .4 severe.

4/ Injury (russet) classified as 12.0 slight; 6.3 medium; 4.0 severe.

Kryocide was also used in the same manner with Phenothiazine. These tests were checked against lead arsenate 3-100 with Fluxit 1/4-100 and lead arsenate 3-100 with light oil 3/4% in the 1st, 2nd and 3rd covers with the 4th and 5th covers employing Fluxit only with the lead. For the first time in applying the sprays, particular attention was given to the spraying of the lower leaf surfaces as we have found that 75% of the codling moth eggs are deposited on the lower leaf surfaces of the Newtown variety. (See Table 2). The results obtained in these tests are shown in table 1. As was the case in 1942, Phenothiazine, 1/2-100 employed with lead arsenate at 2 lbs. to 100 gallons, gave superior control as compared to the standard lead arsenate 3-100 with

Fluxit 1/4-100. In 1942 there occurred 1.2% wormy fruit and 8.5% "stings" with 90.5% of the fruit clean. In 1943 this combination produced 2.4% wormy fruit and 9.8% "stings" with 88.4% clean. For these two seasons, the lead Fluxit combination produced the following: 1942, 1.7% wormy fruit, 16.3% stung, 85% clean. In 1943, 2.3% wormy, 17.4% stung and 81.0% clean. Kryocide, 2-100 employed with 1/2 lb. of Phenothiazine and used for the first time this season, likewise produced very promising results. In fact less damage was recorded in this test than the others. In this experiment, 1.9% wormy, 9.6% stung and 88.8% clean fruit developed. Kryocide used in comparable tests with lead arsenate in the past, has always been somewhat inferior as compared to control obtained with the arsenical.

A summary of a 10 year study made from 1926 to 1935 comparing lead arsenate alone with Fluxit spreader and lead arsenate employing oil in from two to three applications per season for first brood control, indicated that the oil as used was productive of little improvement in codling moth control on the Newtown variety, the principal sort in this area. During this period, the average worm injury that developed was as follows: Lead arsenate - oil 1.4% wormy, 8.1% stung; for lead-Fluxit, 1.5% wormy, and 9.6% stung.

Table 2. Egg Laying Habits of codling moth on Apple Fruit and Leaves of unsprayed trees. 1/

Year and Variety	No. weekly examinations	Total leaves examined	Apples examined	Total Eggs	Location of eggs: On Apple	On leaf surface: Upper	On leaf surface: Lower	Parasitism 2/
					Percent	Percent	Percent	Percent
1940	16	4031	718	694	19.3	16.4	64.3	35.9
1941	22	8602	1328	2359	9.7	13.3	77.0	22.4
1942	21	7764	1252	1934	8.1	18.1	73.8	5.7
1943	20	8676	1336	3965	3.5	18.5	78.2	23.3
	79	29073	5634	8852	7.2	16.9	75.4	
Ortley 3/								
1942	20	9731	1197	4957	8.6	49.5	41.7	22.7
1943	18	8968	988	1900	5.9	54.8	39.6	23.6
	38	18699	2187	6937	7.4	51.0	41.0	
Spitz								
1942	1	188	26	43	9.3	44.2	46.5	-
1943	2	828	100	234	7.3	44.5	48.3	-
	3	1016	126	277	7.6	44.4	48.0	
Delic								
1942	1	132	--	54	9.3	44.5	46.3	
1943	1	500	51	186	4.8	40.8	54.3	
Red Grav.								
1942	2	100	--	82	-	29.3	70.7	-
Wintr. Ban.								
1943	3	481	62	118	22.0	25.4	52.5	-

Characteristic of lower leaf surface.
Newtown:- Practically free of pubescence.
Ortley and Spitzenberg:- Noticeably pubescent.
Delicious:- Moderately pubescent.
Red Gravenstein:- Mildly pubescent.
Winter Banana:- Slightly pubescent.

1/ Counts made from leaves growing on fruitbearing spurs only. Winter Banana variety sprayed indifferently in calyx and one cover.

2/ Based upon hatched and parasitized eggs.

3/ Observations made in Mosier district 7 miles East of Hood River in area somewhat warmer and subject to less rainfall.

Less difficulty was encountered in controlling worms during this ten-year period, than has prevailed since that time. In view of the fact that a large percentage of the eggs are deposited on the under leaf surfaces of the Newtown (the variety used in these tests) an attempt was made to cover all of the under leaf surfaces, as well as other areas of the trees in all of the tests. In comparing the results obtained in the arsenate-oil plots with arsenate - Fluxit experiment, a significant improvement was noted; with the former usage, 1.4% wormy and 12.5% stung was recorded; for the lattèr, 2.3% wormy and 17.4% stung. The difference in control was not as great as was anticipated, particularly from the standpoint of "sting" reduction. Evidence that we have been accumulating, indicates that much more moth activity and resulting injury increase occurs after July 1st than prior to that date. In view of the fact the ovicidal sprays have been applied before July 1st, no effects of the oil prevail during the period of greatest need. Due to 2nd brood moth movement throughout the experimental area--including the oil-sprayed plots, doubtless a rather uniform moth population developed in the oil-lead plots as well as the lead plots. As a result of these conditions, outstanding differences in control appear to be lost. Our oil - lead tests have been conducted in a block that has been regularly sprayed over a long period of time with lead arsenate and casein type spreader. With scab control permitting, we propose to reverse the procedure, maintaining lead casein plots in the orchard which will be generally sprayed with oil - lead arsenate.

Bait Trap Moth Catch as Index for Timing Second Brood Cover Spray:

During the early days of moth control in the Hood River Valley, and extending up to the advent of the bait trap (1928 and 1929), it was generally believed that there occurred a period between broods of moth activity (usually July and early August) during which time no spraying was necessary. This was an era of light to moderate infestation as compared to the last 10 years. Three to four cover sprays applied with relatively inferior equipment, resulted in better control than has been obtained recently with 5 covers. In the main, bait trap records have indicated that there occurred approximately a month usually during July and early August at which time moth catches were relatively very low, followed by a rapid increase in the number of moths taken. In the early usage of the traps, the resulting information was used for the timing of the mid-summer or so-called 2nd brood sprays. After several years' usage, it was concluded that the trap was not always a satisfactory medium of expressing hatching activities that were taking place in the orchard. Oftentimes many

new stings were appearing and worms entering at times when the moth catch was low and had been low for some time. A study of egg deposition and hatching was started in 1940. Weekly tabulations have been made beginning with the first egg depositions in the spring and continued throughout the season. The records during 1940 were taken from unsprayed trees in a sprayed orchard; since that time from unsprayed trees in an unsprayed orchard. It was found impossible to collect these data in sprayed orchards because of the relatively small numbers of eggs present and the difficulty of finding the eggs on account of the presence of spray materials. As a unit for standardization purposes, 50 fruit-bearing spurs with their leaves were collected weekly at random from the entire tree. The same trees were used throughout the season for sampling as it was found early in the study that considerable variation in the number of eggs present existed from tree to tree. With the exception of one observation, unhatched eggs were found in each weekly observation throughout the 4-year period.

The data presented in Table 3 is quite typical of observations made during the three previous seasons. Examination of the columns "hatched eggs and total eggs" indicate with the exception of a two weeks period, July 21-28, that rather consistent hatching and egg increase occurred throughout the season. The irregularity appearing in the "unhatched egg" column between the dates July 6th and 28th is doubtless due to increased parasitic development. Eggs that normally would have been classified as unhatched, fell into the parasitized group.

In 1940 and 1943, noticeable second brood egg increase occurred beginning 10 to 12 days prior to the appearance of pronounced increase of second brood moths in the traps. In 1942, egg increases on the tree began slightly ahead of noticeable moth increase in the traps. In 1941, noticeable increase in the numbers of eggs on the trees occurred approximately one week later than noticeable moth trap increase. From these observations, it is concluded that (1) trap catches of the so-called 2nd brood of moths is not a reliable index in timing the first spray employed for 2nd brood control. (2) During many seasons either the trap catches do not express the actual population during the so-called "in-between brood" period, or that moths living through this period deposit many more eggs that those emerging and depositing eggs earlier in the season. (3) There appears to be a period of 10 days to two weeks during which time little egg increase occurs. Prior to the undertaking of this study, we were of the opinion that there existed a period of inactivity of this character of from three to five weeks. (4) Based upon numerous evening orchard observations, there is evidence indicating that at certain times during first brood activity, the occurrence of abnormally high evening temperature very noticeably reduces moth flight activity. There exists some evidence that moths deposit eggs under these conditions accompanied by no extensive flight. Temperature in part may

be responsible for the low indicated by traps, which annually occurs between moths that develop from over-wintering larvae and those of the summer brood. It is conceivable, therefore, that trap records do not express moth population that occurs in the orchards during this period. If moths are not flying under such conditions, mechanical traps would likewise be non-indicative of moth population.

Table 3: Codling Moth Egg Deposition Record. Eggs on Leaves of Unsprayed Newtown Apple Trees 1/ Hood River, Oregon, 1943.

Date of Sampling.	TOTAL		EGGS						
	Apples	Leaves	Hatched	Unhatched	Total	Dead	Parasitized	Upper Surface	Lower Surface
5-18	2/		0	0	0	0	0	0	0
5-25	100	425	0	30	30	0	0	4	26
6- 2	93	474	0	49	49	0	0	15	34
6- 8	94	462	13	50	65	1	1	14	51
6-15	87	445	25	22	53	0	6	20	33
6-22	65	497	30	22	69	5	12	27	42
6-29	70	451	67	14	93	5	7	20	73
7- 6	70	487	77	8	106	2	19	25	81
7-13	69	429	99	14	134	4	17	30	104
7-21	64	460	106	8	130	1	15	19	111
7-28	68	473	106	8	127	3	10	26	101
8- 3	60	452	127	40	198	4	27	48	150
8-10	67	454	142	27	189	2	18	32	157
8-17	57	453	162	41	249	4	42	49	200
8-24	61	453	187	69 3/	307	7	44	55	252
8-30	63	453	191	94	332	8	39	60	272
9- 7	68	452	268	38	400	6	88	74	326
9-14	54	452	266	46	432	12	108	56	376
9-21	58	452	228	10	374	8	128	72	302
9-28	68	452	328	10	496	12	146	90	406
Totals	1336	8676	3422	600	3833	84	727	736	3097
%			63.0	15.6	-	2.9	23.3 4/	19.2	80.8

1/ These records based on leaves from bearing spurs only--50 spurs in each sample. Similar record taken of eggs on apples in this collection, 132 eggs were deposited on the apples surrounded by these leaves.

2/ Examination only; no collection of spurs and leaves made.

3/ Beginning with August 24, leaves were added to the total taken from fruit-bearing spurs in order to maintain a uniform leaf count for the season. The actual record of the observations is shown in Table 3A.

4/ Based upon hatched and parasitized eggs.

Leaf drop of considerable proportions was noticed on the sample of August 24th. In order to graphically express egg laying performance for the season it was necessary to compensate for this loss and the eggs that were likewise lost by bringing up the leaf total to that which had previously prevailed. This was accomplished by picking random leaf samples from fruit-bearing spurs. This corrective sampling was necessary in the case of samples of August 24th and September 7th, 14th, 21st and 28th. Table 3A gives the actual conditions found on each 50-spur sample after leaf fall started, whereas, the corrected figures are presented in Table 3.

Table 3-A

Date of Sampl-ing.	Apples	Leaves	Hatched	Un-hatched	Total	Dead	Para-sitized	Upper Sur-face	Lower Sur-face
8-24	61	400	157	62	266	7	37	52	214
8-30	63	453	191	94	332	8	39	60	272
9- 7	68	406	238	38	364	2	96	70	294
9-14	54	400	232	44	376	12	88	52	324
9-21	58	384	182	4	292	8	94	56	236
9-28	68	286	206	2	306	8	90	48	258

8-24; 50 leaves short; 8-30, no leaves short; 9- 7, 47 leaves short. 9-14, 53 leaves short; 9-21, 68 leaves short; 9-28, 166 leaves short.

Location of Eggs:

Studies were continued relative to egg locations. The findings were found to be consistent with earlier observations and are summarized in Table 2. Twenty weekly observations were made on the Newtown variety beginning with first deposit and extending throughout the season. A total of 3965 eggs were recorded from these weekly standardized samples 1/. Under identical conditions of sampling, and in the same location in this unsprayed orchard, but 1934 eggs (49%) were found in 1942. In 1942 100% injured apples was found on September 9th; in 1943, injury of this amount was noted on September 14th. The

1/ Because of little summer rainfall in this area, eggs persist (shells after hatching) throughout the season, and there occurs, therefore, an accumulation throughout the season. In these studies only leaves growing on fruit bearing spurs, were employed.

percentage found on the fruit was noticeably lower than previously recorded (average of 10.4% for the 3 previous years). In 1943, 78.2% of the eggs were found on the lower leaf surface (73.8% average for the 3 previous years) and 18.5% on the upper surface as compared to the prior 3-year average of 16.9%. This study demonstrated the outstanding importance of covering the lower leaf surfaces of this variety with spray (probably there are others if we knew them) where ovicidal applications are made. It would doubtless be of advantage to spray likewise with non-ovicidal applications that the young hatching larva may immediately contact poison as they start out in search for apples. A weekly study of similar character has been made during the past two years in connection with the Ortley variety. Comparative studies clearly demonstrate the fact egg laying performance varies with varieties. At this time it is believed that physical characteristics of the lower leaf surface of different varieties of apples, govern to a large degree the location of deposit on leaves. Based upon observation involving several sorts of apples, eggs have been found more abundant on the lower surface of leaves that are less pubescent or hairy, than those that are more so. The Newtown is classified as practically free of pubescence, whereas, the Ortley is rated as noticeably pubescent.

Parasitism:

Parasitism by Trichogramma minutum was very different in 1943 as compared to 1942; 23.3% occurred in the former, 5.7% in the latter year. In 1942 no noticeable parasitism occurred prior to August 1st, whereas, during late June and early July, 1943, as much as 25% parasitism was found. Noticeable increase occurred during September. At the time of last observation, September 28, 31% of the eggs were observed to be attacked by the Trichogramma in this unsprayed orchard. This rather extensive parasitic activity exerted apparently little influence on the development of worm injured apples, 95% of which showed worm damage by August 1st. On September 14th, worm damage was found to have increased to 100% with an average of 4.3 injuries occurring on each apple.

Fruit Injury Increase:

Although weekly records were taken throughout the season, involving fruit injury and its increase, the data does not permit making satisfactory relative comparisons concerning egg increase on the trees and the amount of injury that was taking place in the fruit. The percentage of wormy and stung apples (which were not segregated) increased from 1.6% on June 8th to 89.1% on July 21st. This latter percentage was found at the time the traps were taking the least number of moths.

Because of the small numbers of uninjured fruits that were present on the trees, a large number of which were "stings" it is difficult to express graphically, injury increase that was taking place. Regardless of the fact many wormy apples were dropping from the trees from mid-July on to the end of the season which were lost to randomized, picked sampling, a fairly consistent injury increase occurred from July 21st until 100% injury was recorded on September 14th, a condition which obtained to the end of the season. Average injuries per injured fruit were also recorded. From mid-July to mid-August the data does not show consistent increase, undoubtedly due to the fact the more seriously injured apples were dropping during this period and were not present in the randomized picked samples as they had been prior to the occurrence of drop.

Fungicides with the Codling Moth Spray:

In apple growing areas where scab is a problem, the spray program must be a dual purpose arrangement. For many years apple scab has not been a serious disease in the Hood River area, and as a result, little attention has been given to its control. Noticeable increases have occurred during the past two years and it is apparent measures will have to be adjusted to the codling moth control program in order to handle the problem. Based upon results obtained during the past year, and noted at various times in earlier work, certain types of additions to the lead arsenate program employed for codling moth control adversely affect the efficiency of the latter. This influence is demonstrated by results shown in experiments 1 and 2 in the single plot tests, Table 1. Both Bordeaux and copper phosphate produce a rather loose, uneven cover, a type not particularly effective in handling difficult codling moth control problems. The results obtained in these two experiments may be compared with those of S-1 to S-4 which were designed for codling moth control only. A marked difference occurred in the percentage of both wormy and stung fruit. The single plot test No. 3 was designed to control both codling moth and scab. The former was reasonably well attained, however, the Fermate as used in the combination did not affect scab control.

In view of the fact codling moth control appears to be associated with scab control in certain areas, the following is submitted for those who are interested: The most interesting development insofar as apple scab is concerned, was that of scab reduction occurring in some tar oil tests we are conducting for the purpose of changing the alternate bearing habit 2/ and fruit thinning of the Newtown apple.

2/ Tar oil as an agent in changing the alternate bearing habit of the Newtown Apple, Leroy Childs and Gordon G. Brown, 34th annual report Oregon State Hort. Soc. 1942 (Pages 21-34).

Experiments 5 and 6, Table 1, were fruit thinning tests. When approximately 10% of the bloom was open, two tests were applied; one employing 1% and the second 2% tar oil. The entire tree was sprayed with a mist-type coverage. This procedure constitutes a very drastic treatment. Practically all of the foliage, which is rather extensive at this season of the year, was destroyed and the fruit wet was reduced. (21.1% where 1% and 35.0% where 2% tar oil was applied). A reasonably satisfactory crop was produced with no hand thinning. The incidence of scab infection was very materially influenced by these applications. At harvest time but .8% infection was found where 1% tar oil was used and .6% where 2% had been employed. Nearby untreated fruits developed an infection of 7.5%. This same performance occurred in the 1942 tar oil tests. Although the percentage of scab on untreated fruits was limited - 1.96% - a reduction to .15% occurred where 1% tar oil was used and no scab was recorded in the samples taken from the 2% plot.

It is evident that this severe treatment of the trees involves at least two factors insofar as scab reduction is concerned (1) practical defoliation eliminates such primary infection that has occurred on the leaves, and (2) postponement of re-foliation is delayed from two to four weeks after which time weather conditions are not particularly favorable for scab development in this area.

Conclusions.

Based upon a 15-year moth trap record and a 4-year egg deposit study of the codling moth at Hood River, Oregon, the following conclusions can be offered:

(1) Bait trap usage and the resulting moth catch, is not a satisfactory index for the timing of codling moth sprays. This is true for first brood activity as well as the second.

(2) Hatching of first brood eggs occurs as long as 25 days after abundant moth take occurs in the traps. A first cover spray based upon early moth abundance, is oftentimes wasted and the distribution of efficient covers that follow disrupted - especially as related to the use of ovicides.

(3) In three out of the 4-year study, trap catches of so-called second or summer brood moths, were not indicative of egg increase that was taking place in the orchard. Marked egg increase has been noted to occur as much as two weeks prior to pronounced moth take increase. Timing of sprays based upon moth trap records, would be too late for best control.

(4) There appears to occur a rather steady increase in egg abundance throughout the so-called "in between brood" period. This is associated with a steady increase in damage in the form of worms and stings through the period during which time the traps are taking relatively few moths.

(5) The findings appear to explode the idea - common among growers and many of our earlier codling moth investigators - that there occurs a period of 4 to 6 weeks during which time little or no worm activity is taking place and consequently the need of further spray coverage during this period. Performance of bait traps appeared to substantiate the earlier point of view.

(6) It appears at this time that either (a) that limited number of moths, as indicated by the bait traps, deposit many more eggs during the summer than earlier in the season or that the bait traps do not express the actual population that exists in the orchard.

(7) Numerous sundown observations made during early first brood activity, indicate that high sundown temperatures (80° or more) greatly affect codling moth flight. Under these conditions, the egg-laying moths have been noted to hover about and run around over fruit and leaves of fruit bearing spurs and indulge in a very limited amount of flying. These observations suggest the possibility that traps during mid-summer do not express the moth population existent due to limited flight activities.

(8) Bait traps are of value in expressing abundance of moths in orchards and stimulate growers to more and better spraying.

(9) To those who have the responsibility of timing sprays for growers, a seasonal knowledge of egg deposit and condition appears to be far superior to the utilization of traps for this purpose.

(10) Location of codling moth eggs on trees has been found to vary with different varieties. The degree of pubescence on the under leaf surface appears to be the factor governing location of deposit. For example, 75% of the eggs on the Newtown, a smooth surfaced variety, are deposited on the lower leaf surface, whereas, Ortley with a noticeably pubescent (hairy) lower leaf surface, but 41%. Relatively few eggs are deposited on the fruit; 7.2% on Newtown and 7.4% on Ortley. No eggs were found on the leaves of fruit spurs on non-bearing trees adjacent to bearing trees. The codling moth is extremely selective in this respect.

(11) Knowledge of egg locations has a very definite bearing on spraying practice. Where ovicides are employed, it is obvious that the underleaf surfaces should be covered. Coverage of this type would probably be desirable in the case of other spray usage in order that the young hatching worms may immediately contact the poison.

(12) During the 4-year study, parasitism by the egg parasite T. minutum was found to vary from 5.7% to 35.9%. In 1943 with an average parasitism of 23.3%, (31.0% at harvest time) 100% codling moth damage was reached September 14th. This parasite appears to be of little or no economic value as it occurs in nature.

PENNSYLVANIA

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SEASONAL CONDITIONS AND STATUS OF CODLING MOTH INFESTATION DURING 1943

After a cold April and a wet period in May (6.21 inches May 10-31) the growing season was hot and dry. Rainfall for June through September was 6.02 inches, 37 percent of normal for the station. September, with 0.46 inches rainfall, was the driest month. This, and high temperatures produced severe drought conditions in local orchards. Mean maximums of 86.5, 86.5, 88.3 and 78.2 and mean minimums of 64.0, 62.7, 60.8 and 51.3°F. were recorded for June, July, August and September, respectively. June averaged 5°F. above normal, the warmest recorded for this locality

Light crops in three fourths of the orchards reduced the yield in Southern Pennsylvania to about 35% of the 1942 crop. As usual, local orchards at more than 1000' elevation suffered little from codling moth after one or two cover sprays. Variations of less than 1% to more than 50% loss from codling moth occurred between orchards on the low hills at 600' to 800' elevation. Several of the moderately infested orchards of 1942 responded well to treatment with lead arsenate in 1943 but losses were generally about twice as great as in 1942. Much of the expected late injury was prevented by unseasonably cool nights after September 10.

CODLING MOTH BIOLOGY AND BEHAVIOR

Emergence and bait pail records: Spring brood emergence occurred in cages May 14 to June 22 at Arendtsville. Emergence was 25% complete May 29, 50% complete June 5, 75% complete June 7. Earliest emergence was noted from corn stover mulch on May 10 and latest emergence from deep wounds of scaffold limbs of dense foliaged trees June 29-30.

First brood moth emergence occurred July 8 to August 20 with 50% emerged by July 25. Some second brood moths emerged in late August and early September.

Moths were taken from bait pails May 18 to October 8 but bait pails were only helpful in timing the first two cover sprays. The addition of 1-500 nicotine sulfate to one side of each of 21 double quart traps of molasses-benzoate of soda bait increased the catch by almost 10% for the season and speeded the examination of moths for sex.

Height of catch in baits: A 24 ft. tree was baited with double 2 oz. traps hung at 1 ft. intervals from 5 ft. above the top to within 5 ft. of the ground. Traps were operated 4 weeks starting May 15 for spring brood moths and 4 weeks starting July 20 for first brood moths, 318 being trapped in these periods. Forty-four were trapped above the treetop, 200 in the six levels from the top to 5 ft. down, and 305 above the 12 ft. level. The greatest number at any level (40) was recorded 2 ft. below the top while 35 each were taken at the top and 1 ft. above the top of the baited tree. The average height of catch in the 24 ft. tree was 20.6 ft.

Periods of attack: In one test orchard, codling moth eggs averaged 51 per 100 fruit spurs at the time of first entry on May 29 (17 days after petal-fall of Stayman). On thin foliaged trees and on SE slopes, the first wave of attack was well underway by June 1. Delayed hatching occurred on some slopes and in most low-lying orchards where stings were not found until June 3. There were no well-defined peaks of hatching but in test orchards the greatest activity occurred in the periods of June 1-7 and June 16-24. Little hatching took place during two cool periods, June 8-10 and June 30 to July 3, and between broods July 8-15.

Second brood attack occurred daily from July 15 to August 24. The attack was light from August 24 to September 10 in most orchards. Fresh entries were rarely found after September 10 in contrast to 1942. Larvae were taken in bands twice weekly from June 19 to October 15. Worms were most numerous in bands in late August and early September.

CONTROL EXPERIMENTS

Sprays against mature larvae, pre-pupae, pupae and adults: Scales of bark on trunks and branches loosen rapidly with growth of trees after petal-fall and sprays applied at this season might be expected to reach cocoons more readily than earlier applications.

Three pounds of ground cube' (5% rotenone) with 1 pt. mannitan monolaurate per 100 gallons of spray applied to the trunks and main branches of trees left a heavy deposit of material around cocoons in these regions. Emergence of moths from collections of sprayed cocoons was 74% compared with 92% emergence from unsprayed cocoons. The mixture used here was highly effective in killing adult moths that were recovered on sheets beneath trees within 30 minutes after spraying. Nicotine sulfate at 3/4 pt. per 100 gallons as used in Schedule 5, table 1, knocked down many moths in first and third covers and none in second cover.

Sprays of the standard tank-mix nicotine bentonite and sprays of the cube'-mannitan monolaurate mixture were ineffective in preventing cocooning of larvae when applied to trunks and main branches on June 19 and 29 on heavily infested, scraped and banded trees.

Methods used in comparing cover spray schedules: Control experiments were conducted on individual broods. The heaviest available infestations were used. These were located on SE and Eastern slopes of low hills within 2 miles of Arendtsville, Pa. at 750' elevation.

(a) First brood tests: The block of 50 year-old Stayman used for first brood tests had carried a full crop in 1942 averaging about 3000 fruits per tree. The fruits were not harvested in 1942 due to a heavy worm population of 105 per 100 fruits after a heavy arsenate program applied to the lower portions of trees. The trees were filled with bloom in 1943 but the set was light except in the top portions of trees. Eighty-three trees, 20-24 feet high were included in the test block. Twenty-three were culled out as unsuitable but were sprayed as in schedule 8, table 1. Twelve first brood schedules beginning with the first cover spray were applied to single tree plats in 5 replicates. Early sprays of lime sulfur-lead arsenate, ending with the calyx spray, were applied by

the orchard crew but sparingly to the tops of trees. Test sprays were applied by the laboratory staff.

Scoring of 50 fruit samples per tree from the inside tops was done at the start of a late June drop on June 12 to record the effects of the first two covers to that date.

All drops falling between June 12 and July 8 were scored for codling moth injuries. Picked samples were taken from each tree on July 8 and held for 3 days before scoring to increase ease of distinction between worms and stings. One hundred fifty fruits were taken from the upper half of each tree, 75 from the inside top and 25 from the outer portions of the tree at each of 3 locations from ladders 15-18 ft. above the ground. Later drops and fruits knocked down during the harvest season were counted to obtain totals of fruits per tree.

(b) Second brood tests: Second brood tests were run in a block of 18 year-old Stayman bearing a moderate and well distributed crop of fruit. Three first brood covers had been applied by the grower ending June 22. First brood worms averaged 7 per 100 fruits with most entries occurring during the first week in June when the tops of trees carried a light spray residue. An early second brood attack was expected and spray applications were planned to cover the peak of expected attack. Test sprays were applied July 20 and 29th over a residue of bordo-lead arsenate remaining from early cover sprays. Stings were not numerous in the lower portion of the trees by July 15 and few wormy apples were within reach of the ground. At the initial count of July 21, 1 day after the first of the two second brood sprays, all wormy apples on count branches were removed before scoring a 50 fruit sample from each tree. Counts were taken from the ground on 5 fruits from each of 10 branches at 4 day intervals on each tree between July 21 and August 26. Only total injuries were recorded until August 26. At this date, a classification of worms and stings was made by cutting into suspected entries, these over a quarter of an inch deep being classed as worms.

An additional estimation of infestations on count trees was taken by banding, counting and removing larvae entering bands at 10 day intervals until after harvest.

RESULTS OF TESTS ON SINGLE BROODS

Unconditioned, micronized phenothiazine in combination with lead arsenate (schedule 10, table 1) and (treatments 5 and 6, table 2) gave results superior to other materials and mixtures tested. As used in these experiments, phenothiazine and lead arsenate were mixed dry, then wet with water added slowly while stirring through the crumbly stage to a smooth paste. The resulting mixture despersed readily when added to a near-full tank of water. No injury was observed from the use of phenothiazine as used in schedule 10, table 1; dark green foliage hung on the trees until November and fruit was of good finish at harvest. The visible deposits of the mixtures used in both first and second brood tests were persistent but weathered to a chalky residue that could be removed readily by brushing within 4 weeks after treatment.

DN-111, as used with lead arsenate in the first two cover sprays appeared to eliminate late arsenical injury to foliage and afforded a high degree of protection against stings and worms (schedule 9, table 1) for the first two weeks of attack but it was of no value alone against second brood worms, (treatment 2, table 2)and greatly depressed the effectiveness of lead arsenate in second brood sprays (treatment 4, table 2). Apparent contradictory results against codling moth with DN-lead arsenate combinations between first and second brood tests may be due partly to the character of the underlying spray residues preceeding the sprays. However, DN-111, when used with basic lead arsenate on peach produced a residue that was ineffective after weathering, whereas the fresh deposits fed to caged adults brought death more quickly than basic lead in other combinations.

Numbers of several leafhoppers were reduced by DN-111 in the sprays used, while European red mite control compared favorably with that obtained from 5 qts. summer oil and 1 1/2 lbs. Black Leaf 155.

Increased dosage and numbers of applications of nicotine sulfate added to lead arsenate in first brood sprays appeared to improve control but full benefits against moths could not be observed in single tree plats. White apple leafhoppers were mostly killed by 3/4 pt. nicotine sulfate in the second cover only and by 1/2 pt. per 100 gallons of spray in each of the first two covers. A common and troublesome leafminer, <u>Lithocolletis crataegella</u> Clemens, previously reported as being controlled by fixed nicotine in second and third covers, was substantially reduced in numbers where either nicotine sulfate or the fixed nicotines were used in 2 of the first 3 cover sprays. Differences were not obscured by the development of later broods. October foliage in some orchards

contained large numbers of these leafminers, one large block averaging more than 5 per leaf by mid-October. Greatly increased infestations of wooly aphis on terminals and fruit spurs in scattered orchards offer justification for more liberal use of nicotine in the first brood cover sprays applied for codling moth.

Commercial tests of tank-mixed nicotine bentonite: The mixture and schedule (as in schedule 12, table 1) previously used successfully on commercial blocks did not offer sufficient protection through the prolonged period of codling moth attack in 1943. Stings were extremely difficult to find in most blocks where the schedule was used up to 17 days after the third cover spray. However, the change to lead arsenate-bordo-oil in fourth cover was inadequate in preventing injury immediately after its application. In one instance, 2 additional covers of lead arsenate were required before a high proportion of successful entries were avoided. In another instance on Rome, worms of the second brood were 30 times more numerous than first brood worms in spite of 5 weekly applications of 2 qts. summer oil and 6 oz. nicotine sulfate starting in mid-July. It was also evident that lime sulfur should not be used in the first cover preceeding this tank mixture on most varieties. Oil-sulfur injury appeared within 2 days after the second cover on varieties that bore broad leaves at the time of first cover. Such injury was most pronounced on Stayman, slightly less on Smokehouse, Wealthy and Yellow Transparent. It did not appear on Red Delicious, Romes and Yorks. Similar oil-sulfur injury occurred where deposit builders were used in second cover following lime sulfur and where summer oil was used in third cover sprays after lime sulfur in first cover.

Abbreviations and source of materials listed in tables 1 and 2:

Pheno - Phenothiazine, micronized, unconditioned by E. I. DuPont.
DN - DN-111, a dicyclohexylamine salt of DNOCHP by Dow.
SO - Summer oil, a low cost type by Miller Chemical Co.
LA - Corona brand lead arsenate by Pittsburg Plate Glass Co.
NS - Nicotine sulfate by Tobacco By-Products Co.
155 - Reg. grade B.L. 155 " " " "
NNO - Mannitan monolaurate by Atlas Powder Co.
LLS - Liquid lime sulfur by Adams Co., Fruit Packing and Dist. Co.
MS - Manganese sulfate, Tecmangam, by Tennessee Eastman Co.
SF - Duspray soya flour by Central Soya Co.
TMNB - Tank-mixed nicotine bentonite of: Wyoming bentonite, 5 lbs., Nicotine sulfate 1 pt., Soy bean oil 1 qt.

Table 1: First brood tests, Keller Farm Orchards SW., Arendtsville, Pa.

Sch.* No.	Materials and rates per 100 gals. of spray: 1st Cover 5/28	2nd Cover 6/3	3rd Cover 6/14	Fruits per tree	% Clean 7/8	Injuries per 100 fruits 6/12	Injuries per 100 fruits 7/8	Worms per 100 Fruits 7/8
1.	LA - 3 lbs. LLS- 1 1/2 gals. MS- 4 oz. SF- 4 oz.	LA- 3 lbs.	LA- 3 lbs. Bordo- 1-5-100	Drops: 730 Total- 1350	55 42	 31	76 151	26 22
2.	As 1	As 1	As 1 plus SO- 3 qts.	Drops: 719 Total- 1583	59 48	 29	69 119	21 13
9.	LA- 3 lbs. DN- 20 ozs.	LA- 3 lbs. DN- 20 ozs.	As 2	Drops: 481 Total- 972	86 65	 2	18 78	6 6
10.	LA- 3 lbs. Pheno- 2 lbs.	LA- 3 lbs. Pheno- 2 lbs.	As 2	Drops: 748 Total- 1901	89 73	 3	13 46	3 2
3.	As 2 plus NS- 1/4 pt.	As 2 plus NS- 1/4 pt.	As 2 plus NS- 1/4 pt.	Drops: 375 Total- 955	63 48	 21	58 121	19 11
4.	As 2 plus NS- 1/2 pt.	As 2 plus NS- 1/2 pt.	As 2 plus NS- 1/2 pt.	Drops: 690 Total- 1418	69 56	 20	45 93	14 9
5.	As 2 plus NS- 3/4 pt.	As 2 plus NS- 3/4 pt.	As 2 plus NS- 3/4 pt.	Drops: 558 Total- 1302	66 54	 15	52 96	14 7
6.	As 2	As 5	As 2	Drops: 779 Total- 1676	64 51	 19	57 109	20 14
7.	As 2	As 5	As 5	Drops: 626 Total- 1346	65 55	 20	53 99	19 12
8.	As 5	As 5	As 2	Drops: 654 Total- 1283	75 61	 15	33 79	10 8
11.	LA- 3 lbs.	LA- 3 lbs.	As 2	Drops: 775 Total- 2432	71 52	 10	42 101	10 6
12.	As 1	TMNB	TMNB	Drops: 806 Total- 1380	71 62	 10	40 69	17 17
0.	No sprays after petal-fall			Drops: 1176 Total- 1776	-- --	 85	194 235	186 178

* In addition to the sprays reported above, schedules 1 to 12 inclusive were followed on June 24 with a top-over spray of 1/2-2-Bordo, LA- 3 lbs. SO- 2 qts.

Table 2: Second brood tests, Blue Ribbon Orchards, Arendtsville, Pa.

Treatment Number	Materials and rates per 100 gallons July 20 and July 29, 1943	Increase per 100 fruits* 7/21-8/26 Total Injuries	Increase per 100 fruits* 7/21-8/26 Worms	Worms per tree in bands 8/17-10/15, 1943
0.	Unsprayed (last of 3 first brood covers applied 6/22 of lead-bordo)	206	103	180
1.	LA- 2 lbs.	183	27	67
2.	DN- 20 oz.	186	97	184
3.	Pheno- 24 oz.	72	32	70
4.	LA- 2 lbs. DN- 20 oz.	214	63	125
5.	LA- 2 lbs. Pheno- 24 oz.	42	12	25
6.	LA- 2 lbs. Pheno- 24 oz. DN- 20 oz.	32	13	42
7.	Pheno- 24 oz. NNO- 12 oz.	161	56	142
8.	155- 24 oz. NNO- 12 oz.	212	67	97
9.	155- 24 oz. SO- 5 qts.	91	39	53

*Total fruits per tree after the June drop averaged near 650 per tree.

Spray equipment and materials in 1943: Lead arsenate, copper sulfate, sulfur, lime and nicotine sulfate were available to growers in amounts sufficient to supply the demand if not the need. The demand for spray materials is reduced by the inadequate supply of spray equipment, few growers being able to cover their orchards in less than one week and many requiring 10 days.

Limitations on uses of cube' and derris and certain rotenone sprays caused some growers to lose fruit to pistol casebearer and to the green stink bug.

VIRGINIA

A. M. Woodside, Field Laboratory, Virginia Agricultural Experiment Station, Staunton.

I. The carryover of codling moths in Albemarle and Augusta Counties in the spring of 1943 was one of the heaviest observed in 17 years. First observed emergence was on May 8, about the average date. Frequent rains and high winds prevented efficient spraying during the first-brood period, and the flight had a longer duration than usual. In spite of the fact that moths were present in large numbers and depositing eggs, the catches in bait traps was lower than average. Infestation by the first brood of larvae was very high in most orchards. The period of flight of the first and second-brood moths was very dry, the last rain of any consequence falling on July 15. These conditions, together with a very light crop, resulted in a higher percentage of injury to fruit than has been observed for at least ten years. The population of hibernating larvae is largely dependent on the size of the crop borne by the individual trees. Where the crop approached normal there is a very heavy population.

II. Weekly counts of new infestations on small trees were made in the same orchards where bait traps were located. There was a lag of more than three weeks between the peak of spring-brood moth flight and the time of maximum fruit infestation by the first-brood larvae.

III. B. Last year the results of an experiment in killing larvae in thinned-off fruits was reported. This experiment was repeated, and the results were similar to those in 1942, table 1. The higher mortality of the larvae in the buried fruits and those on the ground was probably due to the excessive rainfall during the period when they were exposed.

Table 1: Results of treating wormy apples to kill the worms, Staunton, Virginia, 1943

Lot No.	Treatment	Number of worms Total	Survived	Control percent
1	Kept in cloth-covered jar in insectary	102	93	--
2	Spread on ground under overturned jar	107	72	25
3	Kept in open pit 4 weeks	115	22	79
4	Buried 2 inches for 4 weeks with PDB 1/	107	00	100
5	Buried 6 inches for 4 weeks	99	3	97
6	Kept in cloth-covered jar 3 weeks with PDB 1/ 2/	109	00	100
7	Buried 6 inches with straw	97	00	100
8	Submerged in water 2 weeks	117	5	95
9	Submerged in oil-covered water 2 weeks 3/	103	00	100
10	Submerged in boiling water 1 minute 4/	116	23	78
11	Submerged in boiling water 2 minutes 4/	107	5	95
12	Submerged in boiling water 3 minutes 4/	109	2	98
13	Submerged in boiling water 5 minutes 4/	97	00	100
14	Kept in cloth-covered jar in insectary	112	99	--

1/ Paradichorobenzene was used at the rate of 1 ounce per cubic foot.
2/ Jar was covered by two thicknesses of heavy domestic held in place by rubber bands.
3/ Water covered by half an inch of used motor oil.
4/ Period of submersion counted from the time water started to boil again after the apples were dropped in.

IV. Growers experienced no great difficulty in obtaining desired spray materials, as these were generally available. Some slight delays reported, and some used a substitute at times. Spray equipment almost unobtainable, and there was very great delay in obtaining needed repair parts in some instances.

VIRGINIA

W. S. Hough, Winchester Research Laboratory, Virginia Agricultural Experiment Station, Winchester.

Codling moth injury was unusually severe in 1943. The apple crop ranged from about 15% to 35% of a normal yield. This fact together with a warm, dry summer largely accounted for the high percentage of injury on the fruit.

The orchard experiments were designed primarily to observe the influence of various spreaders and stickers on lead arsenate in the control of the codling moth, although some non-arsenical insecticides were used in second brood sprays in a few plats. In these tests five replicates were sprayed but because of the absence of fruit on some of the trees only four replicates were used in the final examination. There was no spray injury of practical importance except where lead arsenate was used alone and on these trees defoliation was severe. The results, including drop counts from July 1 to harvest, are summarized in table 1.

Dinitro-o-cresol and dinitro-o-cyclohexylphenol at the rate of 4 ounces per 100 gallons were used with lead arsenate 3 lbs. per 100 gallons in six cover sprays in a heavily infested Stayman orchard, but neither material appeared to add anything to the efficiency of control over lead arsenate plus Bordeaux mixture 1/2-2-100. Severe foliage injury was observed following the use of dinitro-o-cresol 4 ounces and wettable sulfur 5 pounds in the first cover spray.

Table 1: Results of experiments at Winchester, Va.

Note: Lead arsenate 3 lbs. and lime sulfur 2 gals. in calyx spray.

Cover Sprays	Materials per 100 gallons	Percent Wormy	Percent Injured
1-7	Lead 3 lbs.	2.96	30.69
1-3 4-7	Lead 3 lbs. Phenothiazine (micronized) 4 lbs.	2.37	15.60
1-3 4-7	Lead 3 lbs. Genicide 1 1/2 lbs.	12.55	36.78
1-3 4-7	Lead 3 lbs. Black Leaf-155 3 lbs., oil 1 pt.	15.87	42.15
1-7	Lead 3 lbs., $Al(OH)_3$ paste 3 lbs.	1.96	33.19
1-7	Lead 3 lbs., lime 2 lbs. Colloidal-77 6 oz.	.72	15.02
1-7	Lead 3 lbs., lime 2 lbs. Ortho Dry Spreader 1/2 lb.	2.51	23.78
1-7	Lead 3 lbs., lime 2 lbs. Grasselli Spreader 2 oz.	6.12	42.61
1-7	Lead 3 lbs., lime 2 lbs. Soyflour 1/2 lb.	3.78	29.01
1-7	Lead 3 lbs., lime 2 lbs.	2.19	42.18
1-7	Lead 3 lbs., lime 3 lbs.	1.96	35.29
1-7	Lead 3 lbs., lime 5 lbs.	2.90	33.25
1-7	Lead 3 lbs., lime 10 lbs.	8.51	36.65
1-7	Lead 2 lbs., lime 2 lbs.	15.10	51.72
1-7	Lead 4 lbs., lime 2 lbs.	2.83	21.91

Table 1: Continued

Cover Sprays	Materials per 100 gallons	Percent Wormy	Percent Injured
1-7	Lead 1 1/2 lbs., Cryolite 3 lbs. (D-41) 5 oz.	12.06	38.43
1-7	Lead 1 1/2 lbs., Cryolite 3 lbs. (D-296) 5 oz.	11.45	41.46
1-7	Lead 3 lbs., lime 2 lbs., Nufilm 1 pt.	8.35	56.15
1-7	Lead 3 lbs., lime 2 lbs., Nufilm 1 qt.	4.35	44.24
1-7	Lead 3 lbs., lime 2 lbs., kerosene-soap	1.66	49.41
1-7	Lead 3 lbs., lime 2 lbs., kerosene 2 qts. Crude soybean phosphatides 8 oz.	2.95	24.36
1-7	Lead 3 lbs., lime 2 lbs. Crude soybean oil 1 qt.	.28	10.56
1-7	Lead 3 lbs., lime 2 lbs. Spraylastic 1 qt.	7.12	35.60
1-7	Lead 3 lbs., lime 2 lbs., Orthex 1 pt.	1.25	31.74
1-7	Lead 3 lbs., lime 2 lbs., Orthex 1 qt.	3.55	22.83
1-7	Lead 3 lbs., lime 2 lbs., Mixol 1 pt.	2.06	39.81
1-7	Lead 3 lbs., lime 2 lbs. Fish oil 1 qt.	.64	15.95
1-7	Lead 3 lbs., lime 2 lbs. Watkins Dip 2 qts.	4.91	49.25
1-7	Lead 3 lbs., lime 2 lbs. Oil (55 sec.) 1 qt.	3.55	42.04
1-7	Lead 3 lbs., lime 2 lbs. Oil (65-72 sec.) 1 qt.	1.00	17.49
1-7 3,6	*Lead 3 lbs. Bdx. 2-4-100	2.61	35.41
1-7	*Lead 3 lbs., $ZnSO_4$ 1/2 lb., lime 1 lb.	3.64	29.77
1-7	*Lead 3 lbs., (DN-111) 1 1/2 lbs.	6.94	37.86
1-4 1-3 5-7 5-7	*Lead 3 lbs. $ZnSO_4$ 1/4 lb., lime 1 lb. Cryolite 4 lbs. Oil (65-72 sec.) 2 qts.	9.52	36.61
1-4 1-3 5-7 5-7	*Lead 3 lbs. $ZnSO_4$ 1/4 lb., lime 2 lbs. Black leaf-155 3 lbs. Oil (65-72 sec.) 2 qts.	5.47	29.87
Northwest Check (York)		70.72	86.18
Northeast Check (Stayman)		78.85	83.25
Southeast Check (York)		73.32	80.81

*York variety. All other treatments on Stayman and Black Twig varieties.

(D-41) contained 40% dinitro-o-cyclohexylphenol.

(D-296) contained 40% dinitro-o-cresol.

CANADA

Jas. Marshall, Dominion Entomological Laboratory, Vernon, British Columbia.

I. Seasonal Conditions and Status of Codling Moth Infestations in 1943.

In the Okanagan Valley of British Columbia emergence of overwintered moths was protracted by a cool moist spring in 1942. It was even more protracted by a cool and very dry spring in 1943. In fact in 1943, first generation larvae were entering the fruit in mid-July when the second generation normally becomes active. The winter of 1942-43 was very severe. Temperatures in the Vernon area went as low as -30°F. There was high winter mortality in the North Okanagan (about 90%). From Kelowna southwards, temperatures did not drop below -20°F. and mortality evidently did not exceed about 30%. Infestation of the 1943 crop was lower than for two seasons in the Vernon area but in Kelowna it was perhaps slightly higher than in 1942. The Westbank district was more heavily infested than before. Summerland, Penticton and Oliver districts were apparently no more heavily infested than in 1942.

III. Results of Control Experiments - A. Field Work

1. Larvicide Investigations

a) Experimental Set-up. Approximately 5 acres McIntosh. Large trees. Check plots immediately adjoined all experimental treatments. Plots of 6 trees duplicated or 10 trees not duplicated. Part sprayed 6 times, part 5 times. Dosage about one gallon per box of crop trees capable of bearing. All trees in 6 tree plots and 5 trees of 10 tree plots checked at harvest. Five hundred apples sampled per tree.

b) Unusual conditions. Very late first generation activity (Mid-July).

c) Injury to Foliage or Fruit:

Phenothiazine produced abnormally deep green coloration of foliage and fruit when used throughout the season.

Low sulphonation distillate oil (5% U.R.) apparently resulted in abnormally light colored foliage when used at 0.5%.

A heavy oil (175 S.S.U. 100°F.) of low sulphonation (56%) caused some etiolation and defoliation particularly from the first cover spray at 0.5%. It also produced considerable fruit russet.

There was no apparent injury to foliage or fruit from 5 applications of an oil of 73 S.S.U. Vis. 100°F. and 68% U.R. (The type of oil now used almost exclusively in summer codling moth sprays in British Columbia is of under 75 S.S.U. Vis. at 100°F. and approximately 75% U.R. - A.O.A.C.)

Phenothiazine used with 1 quart of stove oil or summer oil caused no unusual symptoms on foliage or fruit i.e. no symptoms aside from those caused by phenothiazine alone.

d) Spray Deposits

Mississippi bentonite-nicotine sulphate, tank mixed and used with 0.5% petroleum oil and monoethanolamine oleate produced a very light though uniform deposit. This mixture should be even more satisfactory when a method is devised for increasing the quantity of deposit.

Phenothiazine wetted by a small amount of stove oil and the whole dispersed by casein-lime, produced a heavy and uniform deposit; the most effective so far observed with this compound. Evidently a hydrophilic colloid is a most satisfactory dispersing (emulsifying) agent for such a mixture.

e) Summary of Results at Harvest

Phenothiazine: One pound wetted by a small amount of stove oil which in turn was emulsified by casein-lime, resulted in decidedly lower infestation than the recommended schedule of lead arsenate 4 pounds, or cryolite 4 pounds, with casein-lime spreader. There are indications that 0.5 lb. of phenothiazine so used, may be as effective as 4 lbs. lead arsenate or cryolite with spreader. In that event, the phenothiazine treatment even with phenothiazine at $1.00 per pound, would be no more expensive than the present schedule. The continued use of lead arsenate is considered a serious matter from the standpoint of soil fertility in the orchards of British Columbia. There are indications that its complete elimination from the codling moth spray schedule will shortly be accomplished by use of cryolite, fixed nicotine-oil, phenothiazine, moth sprays and trunk sprays.

Fixed Nicotine (Mississippi Tank-mixed): An unusual type of bentonite that has the capacity of fixing nicotine yet does not form a tenacious deposit on the fruit when wet-mixed in the spray tank, has recently been reported by the U. S. Bureau of Entomology. Experiments with Mississippi tank-mix at Kelowna in 1943 were encouraging. (Most bentonites must be dry-mixed with nicotine sulphate otherwise they give rise to cement-like deposits on the fruit.)

Addition of Free Bentonite to Fixed Nicotine: When an equal amount of free bentonite was added to the Commercial "Black Leaf 155 Concentrate" in order to increase the quantity of deposit, a most tenacious residue supervened. Codling moth control apparently was not improved (the material was used with 0.5% petroleum oil).

Low Grade Distillate oil as a Summer Spray: A very cheap petroleum oil of about 50 S.S.U. Vis. 100°F., and only 5% unsulphonated residue has been used with fixed nicotine in 1942 and 1943. Although it apparently resulted in lighter-coloured apple foliage than ordinary summer oil, it caused no apparent fruit injury. Codling moth control with this material has been unusually good. Work with this unorthodox oil is to be continued.

2. Tree Trunk Sprays

a) Experimental Set-up. Approximately 7 acres, McIntosh, Wealthy, and Jonathan, treated by spraying tree trunks and scaffold limbs to a height of 6 to 8 feet, in early spring. Subsequently the trees received the ordinary summer larvicide applications. Adjoining blocks that received only the summer applications served as checks.

b) Unusual conditions affecting results. Approximately 90% mortality of overwintering larvae resulted from low temperature (-30°F.).

c) Injury. Three years' investigations suggest that:

i) The portion of the tree trunk most susceptible to injury is the crown.

ii) In petroleum oil-dinitrocresol solution, the oil is the more injurious of the two components.

iii) Light oils (32 to 50 S.S.U. Vis. 100°F.) are more injurious than heavy oils (100 to 200 S.S.U. Vis. 100°F.)

iv) Unsulphonatable residue of an oil seems to be relatively unimportant in this work.

v) A concentration of 100% oil (light) may prove highly injurious even in a single application.

vi) Two successive annual applications of 10% to 20% distillate oil (40 S.S.U. Vis. 100°F.) emulsions containing 2% dinitrocresol by weight of oil have caused no apparent injury.

d) <u>Summary of Results</u>

The series of investigations has led to these generalizations:

i) A light oil(32- 40 S.S.U. Vis. 100°F.) is indicated because of its effectiveness in penetrating the cocoon and its low cost.

ii) A 15% emulsion of 40 S.S.U. Vis. (100°F.) distillate oil containing 2% dinitrocresol by weight thoroughly applied should kill 80% of the overwintering larvae on the treated portions of the tree.

iii) Such mortality should be reflected in a marked reduction of infestation at harvest (over 50% if winter mortality is low to moderate).

iv) It is not yet known if it is advisable to remove the top two inches of soil from the base of the tree shortly after treatment.

v) Cost of treatment, labor included should not exceed 1 cent per box of fruit.

vi) A quick-breaking emulsion seems preferable to a stable emulsion providing agitation is adequate.

vii) For convenient application old spray guns fitted with 18 inch extensions (1/4 inch pipe) 45 degree elbows and 3/64 inch discs have been satisfactory. Low pressure (50-100 lbs.) is desirable.

viii) For most effective utilization of a trunk spray, tree trunks should not be scraped.

3. Foliage Sprays for Moths

a) Experimental Set-up: Approximately 12 acres, McIntosh, Wealthy, Jonathan, Newtown, and Winesap. Ammonium dinitrocresolate (4 oz. dinitrocresol equivalent per 100 gallons) used alone at weekly intervals for two months subsequent to the petal fall or added to ordinary larvicidal applications of lead arsenate or cryolite.

b) Unusual conditions affecting results: An abnormally cool, dry season during flight of moths of overwintered generation.

c) Injury: No injury even where 0.5% petroleum oil applied less than a week following application of dinitrocresol salt.

d) Residue: Practically no residue visible on fruit at harvest.

e) Summary of Results: Unlike 1941 and 1942 (abnormally damp seasons) in which summer foliage applications of salts of dinitrocresol apparently considerably improved codling moth control, 1943 produced no such results. It is suggested that ineffectiveness of 1943 treatments may be due to lack of moisture on the foliage as a result of which the water soluble dinitrocresolate residue was not generally available to the moths.

For the third successive season, application of a salt of dinitrocresol in the usual codling moth larvicide treatments or alone, resulted in approximately 20% increase in size of McIntosh and Wealthy in the North Okanagan Valley. In the South Okanagan, increase in size of Winesap apparently occurred in only one of three orchards. The nature of this unexpected phenomenon is not yet known.

4. Combined Trunk Treatments and Foliage Sprays for Moths

a) Experimental Set-up: Approximately six acres McIntosh and Wealthy received both a dormant trunk treatment to kill overwintered larvae and foliage sprays of ammonium dinitrocresolate or sodium silicofluoride added to the regular larvicide mixtures.

b) Unusual conditions affecting results: Very low winter temperature (-30°F.) killed over 90% of hibernating larvae thus minimizing the effect of the trunk treatment. As far as can be determined, the foliage sprays for moths were almost entirely ineffective presumably because of exceptionally low humidity and precipitation during the flight period of the moths of the overwintered generation.

c) Injury: No injury was evident from the trunk treatments, or from the foliage spray of ammonium dinitrocresolate (4 oz. dinitrocresol equivalent per 100 gallons) but foliage injury typical of arsenical "burn" was pronounced from lead arsenate 4 lb.-sodium silicofluoride 1 lb. mixture. It was determined that sodium silicofluoride may liberate soluble arsenic from lead arsenate.

d) Summary of Results: In one block of treated trees, infestation at harvest was approximately the same as in the check block although the check block which had been the treated block the previous year, had a winter carry-over less than half as great as the treated one. The trunk treatment of 15% distillate oil, the oil containing 2% dinitrocresol by weight, killed approximately 80% of the larvae left alive on the tree trunks after the severe winter. Practically all the survivors had cocooned below snow-line.

In the second block of treated trees, the dormant trunk treatment of 20% distillate oil emulsion containing 2% dinitrocresol, again killed approximately 80% of the larvae that had survived the winter below snow-line. Infestation at harvest on the trunk treatment-foliage spray block of the early harvested Wealthy variety was 3% while on the adjoining check block it was 10%. On the later harvested McIntosh however, averaged infestation on treated blocks was 11% and on check blocks only 13%. This is the smallest difference obtained in 3 years' investigation of these control procedures.

B. Laboratory Work

1. Comparison of Toxicity of Lead Arsenate and Calcium Arsenate.

Calcium arsenate and lead arsenate both appeared more toxic to codling moth larvae when moistened with the juice of immature apples than when dry. The difference between the moistened and dry arsenicals seemed considerably

greater with the calcium compound. It is presumed that in the case of calcium arsenate, there was solubilization by virtue of the acidity of the apple juice. Lead arsenate may have become more toxic by being more rapidly ingested when moist than when dry.

2. Laboratory Experiments with Larvicides

Nicotine "Reineckate" 1 lb., cadmium nitrate 3 lbs., derris powder 1 lb. and cadmium sulphate 3 lbs., all killed more first instar codling moth larvae than lead arsenate 4 lbs. Addition of ammonium dinitrocresolate 4 oz. to lead arsenate apparently improved the effectiveness of the arsenical somewhat. Nicotine "Reineckate" caused no injury to the fruit but the cadmium salts caused injury. The fluoride, acetate, carbonate and chloride of cadmium were not as effective as the nitrate and sulphate.

3. Laboratory Experiments with Moth Insecticides

In order of decreasing apparent effectiveness in killing codling moth adults were the following: Nicotine sulphate 0.5 pint, nicotine "Reineckate" 1 lb., sodium silicofluoride 1 lb., nicotine bentonite 4 lbs., Reinecke salt 3 lbs., dinitrocresol acetate (sat. soln.) cadmium salts (acetate, chloride, nitrate, sulphate, carbonate) 3 lbs., derris 2 lbs., triethanolamine dinitrocyclohexylphenate 4 oz. and dicyclohexylamine dinitrocyclohexylphenate 4 oz.

IV. Experience of Growers in Obtaining Insecticides and Spray Equipment.

No difficulty in obtaining the necessary codling moth insecticides but insufficient new power sprayers available.

DOW CHEMICAL COMPANY

O. H. Hammer, Midland, Michigan

CODLING MOTH AND RED MITE CONTROL STUDIES IN SOUTHWESTERN MICHIGAN, 1943.

Apple growers and packing house managers in Western Michigan have reported that the codling moth damaged a larger part of the crop in 1943 than has been the case during the experience of these informants. Of the various apparent reasons for this situation the follow-

ing are probably among the most important: (1) a general light crop, (2) heavy early season rainfall which made it difficult to apply and maintain adequate protection during the first part of the first brood entry period, and (3) the shortage of labor and equipment parts, thereby accentuating poor timing of the applications. A moderately cool period during late summer and autumn apparently greatly aided in preventing even more serious damage.

The codling moth control data presented in this report show the results obtained in three orchards. While these plots were designed mainly for codling moth control studies, observations on European red mite infestations and spray injury to the fruit and foliage are briefly presented.

EXPERIMENTAL ORCHARDS: The Warner orchard (table 1) consisting of 20 to 25 year old Delicious trees was sprayed throughout the entire season by the investigators. The planting was divided into two blocks, about square in outline and of about equal size. Each spray schedule was applied to a section of a row of four record trees in each block; thus the data for a single plot was based on results from eight trees. The 1943 crop varied from 1/4 to 1/2 of a full crop.

The variety in the Leisenring orchard (table 2) was Duchess. Individual plots consisted of blocks 16 tree rows long and 5 rows wide. Record trees were selected at random from the three center rows. The crop on the record trees varied from about 1/3 to 2/3 capacity. This type of plot was used since an attempt was made to determine how much, if any, codling moth control could be attributed to the use of DN-111 as a supplement to lead arsenate, and such arrangement tends to minimize the effects of moths migrating from plots of poor control to those of better control. Due to poor timing and incomplete coverage, a considerable infestation had become established before the first experimental treatments were applied on June 22.

The Seeley orchard (table 3) consisted of a block of large McIntosh trees about 30 years old. This planting was reported to have a serious codling moth infestation which proved to be even more formidable than seemed reasonable. The grower applied a regular spray schedule to the trees prior to the first experimental treatment of June 10. On this date a considerable codling moth infestation had become established, and the intensive spray schedules used for the remainder of the season gave very poor control. The plots in this planting consisted of single randomized trees replicated five times.

EXPERIMENTAL PROCEDURE: All sprays were applied with equipment capable of delivering 30 to 35 gallons per minute and operating at 550 to 600 lb. pressure. Single nozzle guns were used and the spraymen rode the rig except in plot 11 in the Seeley orchard in which case the spraying was done from the ground. One or two spraymen worked on each rig and this as well as their position on the rig was determined by the size of the trees and the ease of securing good coverage. Control data were obtained, both picked and dropped fruits, in a manner similar to that described by Newcomer et. al. in U. S. Bureau of Entomology and Plant Quarantine paper ET #215, November 1943.

RESULTS: Results are summarized in tables 1, 2, and 3. Arsenical injury to fruit and foliage was of little or no consequence in any of the plots discussed in this report. The use of B-1956 (Rohm and Haas) with arsenate of lead apparently increased control (plot 10, table 3). Codling moth control was little affected by the use of DN-111 (Dow Chemical Co.) with arsenate of lead when compared with lead-lime-zinc plots. Some plots show increases in control (plot 10, table 1; plots 4 and 5, table 2; and plot 6, table 3). On the other hand, decreases in control are evident for plots 6 and 18 in table 1. The reason for these results is not fully understood. The use of DN-111 with sulfur and lead arsenate in the first cover spray during a period of high temperature resulted in minor injury to the tips and margins of young leaves. This injury was masked by new growth by July 1. Applications of DN-111 beginning with the 2nd cover and thereafter caused no injury at temperatures encountered during 1943. The full season use of sprays containing DN-111 and arsenate of lead resulted in relatively light visible residues on both fruit and foliage with the fruits seemingly carrying the larger deposit. Red mite control was good and the foliage remained green throughout the season where DN-111 and lead arsenate was used, whereas the foliage was severely bronzed where DN-111 was not used. In the Warner orchard the trees heavily infested with red mite prematurely dropped much fruit and foliage.

Table 1: Warner Orchard - Delicious 1943

Field Plots	Materials Used	Spray dates and Amounts per 100 gals. 1st Cover June 11	2nd Cover June 21	3rd Cover July 1	4th Cover July 13	5th Cover July 26	Percent of crop Clean	Wormy	Stung	Average per 100 apples Worms	Stings	Mites per leaf 6/30
10	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.	82.5	1.9	16.5	2.54	24.3	0.2
	Zinc sulfate	0	0	1 lb.	1 lb.	1 lb.						
	Lime	0	0	3 lb.	3 lb.	3 lb.						
	DN-111	20 oz.	20 oz.	0	0	0						
3	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.						
	Zinc sulfate	0	1 lb.	1 lb.	1 lb.	1 lb.	81.3	1.5	17.7	1.59	26.9	28.1
	Lime	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.						
17	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.						
	Zinc sulfate	0	1 lb.	0	1 lb.	0	80.0	1.7	19.3	2.2	28.9	1.8
	Lime	0	3 lb.	0	3 lb.	0						
	DN-111	15 oz.	0	15 oz.	0	15 oz.						
18	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.						
	DN-111	15 oz.	15 oz.	15 oz.	15 oz.	15 oz.	75.0	1.6	24.2	2.6	39.3	0.4
6	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.						
	Zinc sulfate	0	0	0	0	0	69.8	2.9	28.4	4.1	45.6	4.8
	Lime	3 lb.	0	0	0	0						
	DN-111	0	15 oz.	15 oz.	15 oz.	15 oz.						
21	DN-111	15 oz.	15 oz.	15 oz.	15 oz.	15 oz.	42.7	38.4	42.1	79.0	76.0	0.1

Table 2: Leisenring Orchard - Duchess 1943

Field Plots	Materials used and amounts per 100 gallons	Application dates	Percent of apples			Average per 100 apples		Red mites per leaf	
			Clean	Wormy	Stung	Worms	Stings	July 10	July 30
4	Lead arsenate 3 lb. DN-111 15 oz.	June 22 July 1, 12, 23 August 4	76.3	13.6	12.1	17.1	15.7	.8	0.6
6	Lead arsenate 3 lb. Zinc sulfate 1 lb. Lime 3 lb.	June 22 July 1, 12, 23 August 4	74.2	12.4	16.0	15.5	20.7	32.5	36.8
5	Lead arsenate 2 lb. DN-111 15 oz.	June 22. July 1, 12, 23 August 4	70.4	17.3	15.2	22.7	19.5	1.04	0.1
3	Lead arsenate 2 lb. Zinc sulfate 1 lb. Lime 3 lb.	June 22 July 1, 12, 23 August 4	59.8	23.8	21.4	32.4	29.0	18.3	25.9
7	Dust Lead arsenate 20% Sulfur(325-mesh) 80%	June 22, 30 July 9, 19, 30 August 10	54.4	36.2	14.2	55.8	17.5	10.7	28.0

Table 3: Seeley Orchard - McIntosh 1943

Field Plots	Materials Used	1st Cover June 10	2nd Cover June 21	3rd Cover June 29	4th & 5th Covers July 7 and 19	6th & 7th Covers July 27 Aug. 5	8th & 9th Covers Aug. 16 and 30	Percent of Apples Clean	Wormy	Stung	Average per 100 apples Worms	Stings
	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.					
	Copper sulfate	0	0	2 lb.	0	0	0					
10	Zinc sulfate	0	1 lb.	0	1 lb.	1 lb.	1 lb.	5.8	41.7	89.8	76.7	487.0
	Lime	3 lb.	3 lb.	4 lb.	3 lb.	3 lb.	3 lb.					
	B-1956	0	0	1/4 pt.	1/4 pt.	1/4 pt.	1/4 pt.					
	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.					
6	Lime	3 lb.	0	0	0	0	0	4.4	46.4	92.2	79.3	482.0
	DN-111	0	15 oz.	15 oz.	15 oz.	15 oz.	15 oz.					
	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.					
11	Copper sulfate	0	0	2 lb.	0	0	0	3.8	46.7	92.8	91.4	536.0
	Zinc sulfate	0	1 lb.	0	1 lb.	1 lb.	1 lb.					
	Lime	3 lb.	3 lb.	4 lb.	3 lb.	3 lb.	3 lb.					
	Lead arsenate	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.	3 lb.					
	Copper sulfate	0	0	2 lb.	0	0	0					
3	Zinc sulfate	0	1 lb.	0	1 lb.	1 lb.	1 lb.	6.4	58.4	93.8	131.0	530.0
	Lime	3 lb.	3 lb.	4 lb.	3 lb.	3 lb.	3 lb.					

GENERAL CHEMICAL COMPANY

M. M. Darley and H. L. Rideout, New York City

I. Seasonal conditions and codling moth abundance.

In the Glassboro test orchard there was a heavy carry-over population. Adult emergence (as shown by bait trap catches) began May 16th, continued to June 27th (with major peaks May 27th and June 15th), subsided until July 9th, then continued at an appreciable level until August 23rd; thereafter an average of 2 moths were caught daily in 6 traps until September 15th, 6 days before Delicious harvest began. Severe drought conditions characterized the latter part of the season. The crop on Delicious trees varied from light to moderate, was heavy on Rome and moderate to heavy on Stayman.

In Washington, the Wenatchee test orchard had an average crop, the Yakima orchard a light crop.

III. Results of Control Experiments.

1. Glassboro, New Jersey

Materials Per 100 Gals. in 5th & Later Cover Sprays* (approx. 20 gals. applied per tree in cover sprays)	Per 100 Drops & Picks** Clean	Stung	Wormy
1. Lead arsenate 3#, Filmfast 1/2# in 5th to 9th, hyd. lime 6# in 5th, 7th and 9th, 3# in 6th and 8th; Sum. oil 1 qt. in 5th, 3 qts. in 8th.	52	44	8.9
2. Commercial fixed nicotine 1 1/2#, Sum. oil 2 qts. in 5th to 11th.	52	38	15.3
3. Same mixture as above in 5th to 12th.	61	30	12.9
4. Genicide*** 1 1/2#, Genifilm "A" 1#, kerosene 2 qts., Genifilm "B" 4 oz. in 5th to 11th; lead arsenate 1/2# in 5th to 7th.	61	35	6.6
5. Genicide 3/4#, com. fixed nicotine 3/4#, "A" 3/4#, kerosene 3 pts., "B" 3 oz. in 5th to 11th.	47	47	14.4
6. Genicide 3/4#, phenothiazine 3/4#, "A" 3/4#, kerosene 3 pts., "B" 3 oz. in 5th to 11th.	25	61	42.7
7. Genicide 1 1/2#, "A" 6 oz. kerosene 3 pts., "B" 2 oz. in 5th to 11th.	60	37	7.0
8. Genicide 1 1/2#, "A" 1#, kerosene 2 qts., "B" 4 oz. in 5th to 11th.	65	29	8.7
9. Same mixture as above in 5th to 12th.	68	29	4.9

*Following lead arsenate 3# in calyx spray, 4 lbs. in 1st and 2nd, 2 lb. in 3rd and 3 lbs. in 4th; hyd. lime 3 lbs. in calyx and 4th, 8 lbs. in 1st and 2nd, 2 lbs. in 3rd; Filmfast 1/2 lb. in calyx and 1st to 4th; wettable sulfur 6 lbs. in calyx; nic. sulfate 3/4 pt. in 2nd and 3rd; Summer oil 3 qts. in 3rd, on all plots.

** Includes all dropped apples from July 1st through harvest. Control data given are means for 3 Delicious, 3 Rome and 3 Stayman trees. Replication was by variety.

***Principal active ingredient: xanthone. A given absolute amount of codling moth injury (i.e., a given number of stung apples or stings, wormy apples or worms etc.), when expressed a percentage of the fruits involved, varies inversely with the number of fruits involved. In view of this, control data are given below on a "per tree" basis for the same programs and, for further comparisons, the usual percentage control data based on picked apples only.

Program Number	Picks Per Tree	Per 100 Picked Apples Clean	Stung	Wormy	Per Tree (Drops and Picks) Tot. Apples	Injured	Stung	Wormy
1	1613	55	44	2.9	2113	1003	907	186
2	1544	67	40	7.6	2100	1000	804	322
3	1586	66	30	5.2	1952	764	591	252
4	1240	65	34	2.4	1516	557	499	97
5	1063	50	48	5.6	1462	776	685	211
6	525	37	59	17.3	973	732	593	415
7	1578	63	36	2.4	1885	757	687	131
8	1122	68	30	3.1	1353	470	395	118
9	1799	71	28	1.3	2161	684	622	105

Because they are absolute rather than relative quantities and because they are very much more nearly independent of variations in crop, from tree to tree or plot to plot within a season and from season to season for a given tree, "per tree" codling moth control data appear to be considerably more useful for evaluating the relative performance of different spray programs within a season or of a given program over a number of seasons than the usual percentage control data.

None of the above programs caused any spray injury to either foliage or fruit. Spray residue loads at harvest were as follows:

Program Number	No. Cover Sprays Containing Lead Arsenate	Other (later)	Harvest Residue Variety	Gr. Pb Per lb.
1	9	None	Del.	0.220
			Rome	0.140
2	4	7 Fix. nic. - oil	Rome	0.050*
4	4	3 Lead ars. 1/2# with Genicide and 4 Genicide (7 total)	Stay.	0.045
			Rome	0.032
8	4	7 Genicide	Rome	0.030*
Dup. Plot	4	7 Genicide	Rome	0.028

*It has been noted in previous years also that a late season program of fixed nicotine-oil sprays preserves early season lead arsenate residue to an appreciably greater extent than the same number of Genicide sprays.

2. Wenatchee, Washington

Materials Per 100 Gals. in 3rd & Later Cover Sprays* (approx. 56 gals. applied per tree in cover sprays)	Var.	Per 100 Picked Apples Clean	Stung	Wormy
1. Lead Arsenate 3#, Multifilm 1/6# in 3rd to 6th; (Sum. oil 47.5%, kerosene 47.5%, oleic acid 5%) 1 qt. in 2nd, 5th and 6th; (Sum. oil 95%, oleic acid 5%) 2 qts. in 3rd.	Wine Jon. Del.	66 42 64	25 9 15	8.7 48.0 21.4
2. Genicide 1 1/2# in 3rd to 6th; Genifilm "A" 6 oz., kerosene 1 1/2 qt., Genifilm "B" 2 oz. in 3rd and 4th; "A" 1 1/3 oz., kerosene (5% OA) 3/4 qt., "B" 2 oz. in 5th and 6th.	Wine Jon.	84 77	4 4	12.0 18.5
3. Same as 2 plus Genicide 3#, "A" 8 oz., kerosene (2 1/2% OA) 2 qt., "B" 2 oz. in 7th.	Del.	94	2	3.9

*Following lead arsenate 2 1/2#, Fluxit 1/8# in calyx spray, lead arsenate 3#, Multifilm 1/6# in 1st and 2nd covers, kerosene (5% oleic acid) 1/6 gal. in 1st, and (Sum. oil 47.5%, kerosene 47.5% oleic acid 5%) 1 qt. in 2nd cover spray, on all plots.

3. Yakima, Washington

Materials Per 100 Gals. in 3rd & Later Cover Sprays* (approx. 50 gals. applied per tree in cover sprays)	Var.	Per 100 Picked Apples Clean	Stung	Wormy
1. Lead arsenate 3# in 3rd to 6th, Treoil 2 2 qt. in 3rd to 5th, Treoil 1 2 qt. in 6th.	Wine Del.	61 50	28 29	11.3 21.6
2. Genicide 1 1/2#, "A" 2 oz., kerosene (5% OA) 1 1/2 qts., "B" 2 oz. in 3rd to 5th; Gen. 1 1/2#, "A" 1 oz., kerosene (2 1/2% OA) 1 1/2 qt., "B" 2 oz. in 6th.	Wine Del.	65 67	23 20	12.3 12.7

*Following lead arsenate 3 lb. in calyx, 1st and 2nd covers, Trestik 2/3 pt. in calyx, Treoil 1 1 qt. in 1st, and Treoil 2 2 qt. in 2nd cover spray.

Large unreplicated blocks were used in the Wenatchee and Yakima tests. There was no spray injury in either location. Dropped apples were not collected and examined in these tests.

April 15, 1944

UNITED STATES DEPARTMENT OF AGRICULTURE

Agricultural Research Administration

Bureau of Entomology and Plant Quarantine

RESULTS OF CODLING MOTH INVESTIGATIONS, 1943

Part II

Work Conducted by the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

Not for Publication

(Not for Publication)

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This summary represents the contribution of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine to the pool of information on the results of codling moth investigations carried on during 1943 which has been prepared in accordance with a request made by the Committee on the Codling Moth of the American Association of Economic Entomologists. As in previous years, this is a preliminary report, circulated for the information of those interested. It is subject to revision as further review of the data may indicate, and has the status of unpublished data, not subject to quotation without permission.

The work of the Division of Fruit Insect Investigations is carried on cooperatively with several Bureau and Department units, as well as with a number of State agencies. The Division of Insecticide Investigations has continued to contribute to the work reported herein, and joint field laboratories are maintained at Yakima, Washington and at Vincennes, Indiana. The work in West Virginia is carried on jointly by the West Virginia Agricultural Experiment Station and the Bureau; the work in New York State is carried on similarly with the New York Agricultural Experiment Stations.

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CONTENTS

VINCENNES, INDIANA

L. F. Steiner, In Charge 1/

Seasonal Conditions and Codling Moth Development

The codling moth carryover from 1942 was well below normal. Mortality approximated 20 percent but only a 4 percent mortality of larvae under rough bark resulted from the winter's minimum temperatures of -4 to -8°F. on March 3 and 8 which killed many apple buds and practically all peach buds.

Codling moth emergence began on May 3 and eggs began to hatch between May 18 and 21. Rainfall in May ranged from 8.03 to 9.96 inches in 4 Vincennes orchards. Twenty-one distinct periods of rainfall between May 8 and 25 made conditions ideal for apple scab. Sulfur was therefore used in all sprays applied prior to the first week of hatch, and the effectiveness of poison deposits was unusually low when the change to favorable weather occurred. Rainfall in June, July, and August was 68 percent below normal with only 1/2 to 1 inch occurring in 4 orchards between July 5 and September 2. The mean daily maximum temperatures for the months of June, July, and August ranged from 4 to 10 degrees above normal, the temperature exceeding 95°F. on 25 days in July and August. As a result, particularly in orchards sprayed with lead arsenate, the codling moth built up at a rate seldom before observed in the middle west.

Second-brood larvae were hatching before July 1 with the peak occurring during the second half of that month. The third-brood hatch was at its peak about September 1. Some fourth-brood larvae apparently hatched in certain orchards at Vincennes, Indiana and Henderson, Kentucky where, on October 1, up to 10 fresh injuries were observed on single apples. Although high prices and a 35 to 40 percent crop resulted in a rapid and thorough clean up of drops the present carryover of hibernating larvae is above normal in most orchards.

Laboratory Experiments With Insecticides

Tests, utilizing not less than 40 apples and 400 newly hatched larvae each, were arranged to evaluate new compounds, modifications of established spray formulas, and to compare the relative ability of codling moth larvae from various local orchards to enter unsprayed fruit and fruit sprayed with various insecticides. The best of the spray mixtures developed were subsequently tested under field conditions.

1/ All chemical analyses reported herein were made by J. E. Fahey, Division of Insecticide Investigations.

In a comparison of 2 natural cryolites, the average larvicidal efficiency of 6 treatments was 48.1 percent where a cryolite containing 70 percent Na_3AlF_6 was used and 49.8 percent where the standard product containing approximately 90 percent Na_3AlF_6 was employed. The two cryolites were used at dilutions giving comparable amounts of fluorine.

In tests with several copper and nicotine preparations, cupric benzoate dihydrate gave promise of being a compound that could be used with nicotine bentonite without reducing its effectiveness against codling moth. This is the only copper compound tested to date which did not reduce the larvicidal efficiency of nicotine bentonite. Its fungicidal value is worth testing.

In preliminary tests DDT appeared to be very promising as a codling moth insecticide. Whereas 3 pounds of lead arsenate per 100 gallons of water seldom produces an efficiency above 50 percent, 1 pound of DDT generally showed initial efficiencies ranging from 95 to 100 percent. The results of an experiment to determine the relative resistance of deposits from different formulas containing DDT to tap water sprays are shown below:

Formula	Percent larvicidal efficiency	
	Of original deposits	After 5 tap-water sprays 1/
1. DDT-Pyrophyllite (50-50) mixture 2 lbs.	99.6	98.7
2. Formula 1 plus Bordeaux (1:2:100)	100.0	96.0
3. Formula 1 plus wettable microfine sulfur 4 lbs.	98.2	60.4
4. Formula 1 plus emulsive type summer oil 1 qt.	98.2	98.2
5. Formula 1 plus Wyoming bentonite 2 lbs.	99.6	96.4
6. Formula 5 plus aluminum sulfate 2 oz. and soybean phosphatide spreader 2 oz.	100.0	84.0
Least significant difference	10.0	

1/ Each tap-water spray was equal in volume and force to the original application of the spray mixture. They were applied at 30-second intervals about 15 hours later.

The low efficiency of the sulfur mixture after the tap water sprays does not prove that sulfur and DDT are incompatible. If so, the efficiency of the original deposits should have been reduced.

Nothing was gained by the addition of the supplements in these tests and where a wetting agent was included as in formulas 3 and 6 the DDT deposits were definitely less resistant to the tap water sprays. The compatibility of the DDT-bordeaux and DDT-oil mixtures were later verified in laboratory-field tests.

In preliminary tests, micronized scorodite at 1.5, 3, and 6 pounds per 100 gallons alone and supplemented with weak bordeaux proved to have practically no toxicity under laboratory conditions. Although the 6 pound scorodite formula gave deposits of 20.4 mmg. As_2O_3 per sq. cm., the larvicidal efficiency was only 9 percent. Lead arsenate at 1.5 pounds per 100 gallons left a deposit of 8.9 mmg. per sq. cm. and had a larvicidal efficiency of 38 percent.

Tests of different orchard strains of codling moth larvae were resumed in December as a continuation of the work reported in 1942. Evidence now being obtained indicates that a substantial increase in the apparent resistance of larvae to nicotine bentonite can develop in an isolated orchard population with only 3 years use of this insecticide and that the population meanwhile loses little if any of its previously acquired ability to enter fruit sprayed with lead arsenate.

Laboratory-field Experiments

The method used in conducting these experiments has been described in previous reports and is outlined in detail in Bureau circular E-488 (September, 1939). However, instead of using 80 apples and 640 larvae for each efficiency test the samples were reduced to 60 apples with 600 larvae being used. Some 330,000 larvae were applied in the tests discussed herein.

The trees used for the 2 principal series of tests were of the Rome Beauty and Grimes Golden varieties and were 24 and 23 years old respectively. Prebloom sprays were applied by the grower. An in-bloom spray of 2:4:100 bordeaux was used for control of scab and fire blight. A uniform calyx spray of 3 pounds of lead arsenate, 3 pounds of lime and 6 pounds of wettable sulfur was applied to the Grimes on May 3 and to the Rome Beauty on May 4 and 5. In addition, 3 sulfur dusts and a sulfur spray were applied during the 10 days after petal fall. The trees were sprayed with approximately 30 gallons each per application during the cover-spray period.

The dates of cover spray applications follow:

Spray Number	Series 1 Rome B.	Series 2 Grimes	Spray Number	Series 1 Rome B.	Series 2 Grimes
1	May 21-22	May 19	5	July 2-3	July 6
2	May 28-29	May 27	6	July 15-16	July 23
3	June 4-5	June 8	7	August 2-3	August 12
4	June 14-15	June 17	8	August 19-20	-
			9	August 30-31, September 1	-

Efficiency determinations were made before and after each cover spray beginning with the second, and also at harvest. The Rome Beauty plots were arranged in a restricted randomization of 7 single-tree replicates per plot to provide regular control data (see table 3) and one 2-tree replicate used for the laboratory-field tests.

In this report space does not permit presentation of the individual paired efficiency and deposit determinations. For purposes of comparison, the percent larvicidal efficiencies and weights of fresh and weathered deposits have been averaged separately for the first-brood period and for the remainder of the season. Fresh deposits are those sampled within 3 days after a spray application (usually the same day or the day after). Weathered deposits are based on samples taken from 6 to 17 days after an application, the shortest interval occurring between the second and third cover spray and the longest between the final spray and harvest.

Series 1

Treatments and results on the Rome Beauty variety are given in table 1. A list of abbreviations used to indicate the spray materials included in the treatments shown in that and subsequent tables follows:

301 oil (a raw mineral oil of 85% U. R. and 57 sec. viscosity).

371 oil (a raw mineral oil of 80% U. R. and 72 sec. viscosity).

Bdx. (1/2:1:100 bordeaux mixture).

Cry. 70 (natural cryolite, 70% Na_3AlF_6).

Cry. 90 (natural cryolite, regular).

CSCP (Central Soya Co. crude soybean phosphatides).

List of abbreviations: Continued

CBD (cupric benzoate dihydrate).

DDT (dichloro diphenyl trichloroethane).

DDT-Pyrax (a 50:50 mixture of DDT and Pyrophyllite).

DM-1:10 (dry mix, 1 pt. nic. to 10 lb. KWK powder).

F (ferric dimethyl dithiocarbamate).

FPNB (factory processed nicotine bentonite, 14%).

LA (Lead arsenate).

KWK (Wyoming bentonite, pellet form).

Li (hydrated spray lime).

MDM-1:5 (micronized dry mix, 1 pt. nic. to 5 lb. KWK powder).

MDM-1:10 (micronized dry mix, 1 pt. nic. to 10 lb. KWK powder).

MO (an emulsive 97% mineral oil of 91.0% U. R. and 57.66 sec. viscosity).

Nic. (nicotine sulfate, 40%).

PC (Panther Creek, Mississippi bentonite).

Pheno. (micronized phenothiazine).

S (sulfur, wettable or dusting).

SCP (crude soybean phosphatides).

SF (soybean flour).

SO (soybean oil, crude).

X110 (X110 Mississippi bentonite).

YC (commercial preparation of 55% oil-free soybean phosphatides and 45% carbitol).

ZS (zinc sulfate).

Table 1. Average percent larvicidal efficiencies and spray deposits.
Series 1. Rome Beauty. Vincennes, Indiana. 1943

Plot	Cover sprays	Materials per 100 gallons	Deposits[1]	May 28-July 2 Fresh deposits	May 28-July 2 Weathered deposits	July 3-Sept. 10 Fresh deposits	July 3-Sept. 10 Weathered deposits
1	1	4 lb.LA,4 lb.Li,4 oz.SF.					
	2	4 lb.LA,Bdx.,1 qt. MO		39	44	68	65
	3-4	4 lb.LA,Bdx.,2 qt. MO	As_2O_3	(13.3)	(7.4)	(18.0)	(15.6)
	5-8	3 lb.LA,Bdx.					
	9	2 lb.LA,Bdx.					
2	1	4 lb.LA,4 lb.Li,2 oz.YC					
	2	4 lb.LA,Bdx.,1 qt.MO, 4 oz. YC		47	47	69	67
	3-4	4 lb.LA,Bdx.,2 qt.MO, 4 oz. YC	As_2O_3	(10.7)	(6.8)	(18.1)	(14.6)
	5-8	3 lb.LA,Bdx.,2 oz.YC					
	9	2 lb.LA,Bdx.,2 oz. YC					
3	1-4	2 lb.LA,1 lb. Pheno., 1/2 lb.ZS, 1 lb. Li, 4 oz. SF.					
	5-6	3 lb.LA,1 lb. Pheno., 1/2 lb.ZS, 1 lb. Li, 4 oz. SF		58	35	71	51
			As_2O_3	(6.2)	(3.5)	(13.1)	(11.0)
			Pheno.	(9.2)	(2.7)	(6.7)	(1.7)
	7	3 lb.LA,1/2 lb.Pheno., 1/2 lb.ZS, 1 lb. Li, 4 oz. SF					
	8	3 lb.LA,1/2 lb. ZS, 1 lb. Li.					
	9	2 lb.LA, 1/2 lb.ZS, 1 lb. Li.					
4	1	3 lb.FPNB, 3 lb. S					
	2	3 lb.FPNB, 1 qt.MO		66	55	89	77
	3-4	3 lb.FPNB, 2 qt.MO	Nicotine	(2.3)	(1.0)	(2.5)	(1.5)
	5-9	2 lb.FPNB, 2 qt.MO					
5	1	1 pt.nic., 5 lb.KWK, 3 lb. S.					
	2-4	1 pt.nic., 5 lb.KWK, 1 qt. SO		86	73	95	83
	5-7	2/3 pt.nic., 3 lb.KWK, 1 qt. SO.	Nicotine	(5.3)	(2.8)	(5.1)	(3.9)
	8	2/3 pt.nic., 1/2 lb.KWK, 2 qt. MO.					
	9	2/3 pt.nic., 1/2 lb.KWK, 3 qt. MO.					

Table 1. (Continued)

Plot	Cover sprays	Materials per 100 gallons	Deposits[1]	May 28-July 2 Fresh deposits	May 28-July 2 Weathered deposits	July 3-Sept. 10 Fresh deposits	July 3-Sept. 10 Weathered deposits
6	1	1 pt.nic., 5 lb.KWK, 3 lb.S.					
	2	1 pt.nic., 5 lb.KWK, 1 qt.MO					
	3-4	1 pt.nic., 5 lb.KWK, 2 qt.MO.	Nicotine	82 (5.0)	73 (2.4)	93 (3.8)	87 (2.4)
	5-9	2 lb.FPNB, 2 qt.MO.					
7	1	1 pt.nic.,8 lb.X110, 3 lb.S.					
	2	1 pt.nic.,8 lb.X110, 1 qt.MO.	Nicotine	84 (3.6)	77 (1.5)	95 (5.0)	90 (3.2)
	3-4	1 pt.nic.,8 lb.X110, 2 qt.MO.					
	5-9	2/3 pt.nic., 5 lb. X110,2 qt. MO.					
8	1	1 pt.nic.,8 lb.X110, 1 lb.F.					
	2	1 pt.nic.,8 lb.X110, 1 lb.F., 1 qt.MO.					
	3-4	1 pt.nic.,8 lb.X110, 1 lb.F., 2 qt.MO.	Nicotine	88 (3.6)	81 (1.6)	94 (4.4)	88 (2.6)
	5	2/3 pt.nic.,5 lb.X110, 1 lb.F.,2 qt.MO.					
	6-7	2/3 pt.nic.,5 lb.X110, 1/2 lb.F.,2 qt.MO.					
	8-9	2/3 pt.nic.,5 lb.X110 2 qt. MO.					
9	1	1/2 pt.nic.,4 lb.X110, 3 lb.S.					
	2	1/2 pt.nic.,4 lb.X110, 1 qt.MO, 4 oz. ZS.	Nicotine	69 (2.2)	51 (1.0)	92 (3.2)	79 (2.0)
	3-9	1/2 pt.nic.,4 lb.X110, 2 qt.MO.,4 oz. ZS.					
10	1	1/2 pt.nic.,4 lb.X110, 3 lb. S.					
	2	1/2 pt.nic.,4 lb.X110 1 qt. MO.,4 oz.ZS,8 oz. SCP	Nicotine	77 (2.4)	59 (1.2)	95 (3.9)	86 (2.4)
	3-9	1/2 pt.nic.,4 lb.X110, 2 qt.MO,4 oz.ZS, 4-8 oz. SCP					

Table 1. (Continued)

Plot	Cover sprays	Materials per 100 gallons	Deposits1/	May 28-July 2 Fresh deposits	May 28-July 2 Weathered deposits	July 3-Sept. 10 Fresh deposits	July 3-Sept. 10 Weathered deposits
11	1	1 pt.nic.,8 lb.PC, 3 lb.S					
	2	1 pt.nic.,8 lb.PC,1 qt.MO		83	76	93	79
	3-4	1 pt.nic.,8 lb.PC,2 qt.MO	Nicotine	(3.6)	(1.7)	(4.5)	(2.8)
	5-9	2/3 pt.nic.,5 lb.PC,2 qt.MO					
12	1	1/2 pt.nic.,4 lb.PC,3 lb.S					
	2	1/2 pt.nic.,4 lb.PC,1 qt. MO,4 oz.ZS,8 oz. SCP	Nicotine	66 (2.2)	46 (1.0)	92 (3.2)	77 (2.1)
	3-9	1/2 pt.nic.,4 lb.PC,2 qt. MO,4 oz.ZS, 4-8 oz.SCP.					
13	1	3 lb.MDM-1:5, 2 lb. S					
	2	3 lb.MDM-1:5, 1 qt.301 oil, 6 oz. SCP	Nicotine	73 (2.7)	60 (1.2)	98 (3.9)	92 (2.9)
	3-9	3 lb.MDM-1:5,2 qt.301 oil, 4 oz. SCP.					
14	1	5.5 lb. DM-1:10, 2 lb.S					
	2	5.5 lb. DM-1:10, 1 qt. 301 oil, 6 oz. SCP		64	48	91	82
	3-9	5.5 lb. DM-1:10, 2 qt. 301 oil, 6 oz. SCP.	Nicotine	(2.6)	(1.1)	(3.7)	(2.8)

1/ Deposits as mmg. per cm^2 are shown by figures in parenthesis.

Although treatments such as Nos. 2 (2nd to 4th cover sprays), 10, 12, 13, and 14 had some deposit building tendencies, no over-spraying was done. All were sprayed uniformly inside and out to the point of run-off hence somewhat lighter though more toxic deposits were obtained on these plots, particularly early in the season before the heavier deposits on the others were well filmed by repeated applications. For example the addition of 2 to 4 ounces of a soybean phosphatide-carbitol mixture to the standard lead arsenate bordeaux schedule (2) resulted, early in the season, in a substantial increase in efficiency but a reduction in deposits. This plot produced 75 percent clean fruit compared to 69 percent on Plot 1. The phenothiazine-lead arsenate mixture (3) without oil gave higher initial efficiencies than either Plot 1 or 2, but proved too susceptible to weathering.

The factory-processed nicotine bentonite (4), although but little better early in the season in its larvicidal action than the half strength tank mix (9), gave better control of first-brood larvae probably because of a higher ovicidal effect resulting from the smaller amount of solids in the mixture. Plot 9, however, produced 83 percent clean fruit and plot 4, 82 percent. The latter treatment lost efficiency rapidly late in the season after the drought ended and normal weather prevailed. Between September 1 and 10 the deposits on plot 4 declined from 4.0 mmg. per sq. cm. to 2.1 and the efficiency from 94.1 to 83.2 percent while on plot 9 the respective reductions were from 4.4 to 3.4 mmgs. nicotine and 94.6 to 92.9 percent efficiency. Rainfall was well distributed during this 10-day period and totalled 1.29 inches.

Treatment 5, the standard tank mix nicotine bentonite (Wyoming), soybean oil formula, was also weak near the end of the season after mineral oil was substituted for the soybean oil and the bentonite was reduced. The split schedule used on plot 6 gave results approximately equal to those obtained with No. 5 but was less effective early in the season. This has been characteristic of the Wyoming bentonite-mineral oil formula in previous seasons. Plot 6 averaged 33 worm entrances and 77 stings per tree on June 30 compared to 6 entrances and 56 stings for plot 5.

As in 1942 the outstanding treatment, suitable for immediate adoption by growers, was the Mississippi bentonite, nicotine sulfate, mineral oil tank mix (7 and 11). Although the end results were the same (87 to 88.4 percent clean fruit) regardless of whether the X110 bentonite (7) or the Panther Creek (11) were used it is believed that the former is slightly superior. Treatments 10 and 12 utilized these same bentonites with less nicotine and supplemented with soybean phosphatides and zinc sulfate. The effect of the soybean phosphatides on the X110 Mississippi bentonite formula (9 vs. 10) was to increase the average deposits 20 percent, change the type of coverage from a blotchy to a very smooth film and bring about a very substantial increase in larvicidal efficiency. The Panther Creek Mississippi bentonite (12) with its greater swelling value proved considerably less effective in these mixtures than the X110. Although very promising, because of the ideal film coverage obtained on the fruit, it was evident from these tests that the nicotine sulfate content of such formulas as 10, 12, 13, and 14 should be maintained at the equivalent of 1 pt. per 100 gals. until one or two cover sprays have been applied particularly if, as in 1943, sulfur replaces the oil and phosphatides in the first cover. Plots 10 and 12 each produced 79 percent clean fruit, equalling lead arsenate in worm control and greatly exceeding it in control of stings. However, an average of 25 percent of the worm entrances on plots 10 and 12 were made through or adjacent to the calyx while 17 percent of those on plots 7 and 11 were at that point.

This suggests that the film type coverage stimulates larval movement over the apple so that more find the calyx or that the deposits of these film type coverages in the region of the calyx are disproportionately smaller than obtained with deposits of the blotchy type.

Although the larvicidal efficiencies of the Mississippi bentonite tank mix with ferric dimethyl dithiocarbamate (8) were approximately equal to the regular treatment (7) and the worm populations on June 30 were almost identical, actual control was inferior during the second half of the season, plot 8 producing 83 percent clean fruit compared to 88 percent for plot 7. In setting up this treatment advantage was not taken of the fact that the fungicide could have been substituted for sulfur in the 7-day spray and oil used in the first cover.

The performance of the micronized dry mix (13) with soybean phosphatides was outstanding during the second half of the season (91 percent clean fruit) particularly in view of the saving in nicotine used, but like the other "reduced nicotine" treatments (9, 10, 12, and 14) this formula was less effective early in the season than the standard tank mixtures. Unfortunately, at the present time few growers could make this material and have it micronized. Like on plots 10 and 12 the deposits were in the form of a perfect film but were not conspicuous. The 1:10 regular dry mix (14) was less effective than the micronized product but despite the reduced nicotine content of the spray mixture it was nearly equal larvicidally to the full strength factory processed material. The ovicidal value early in the season was apparently less, however, since control of first-brood worms was no better than obatined with lead arsenate. Control of second- and third-brood larvae was excellent, the efficiency between September 1 and 10 declining only from 98 to 95 percent. The plot produced 81 percent clean fruit.

Series 2

Treatments and results on Grimes Golden are given in table 2. Treatments 1, 5, and 7 of the Series 1 tests were repeated on this variety. Plot 24 is similar, except for the kind of Mississippi bentonite used, to plot 16 in the field tests on Turley (table 4).

Table 2. Average percent larvicidal efficiencies and deposits.
Series 2. Grimes Golden, Vincennes, Indiana. 1943

Plot	Cover sprays	Materials per 100 gallons	Deposits[1]	May 26–July 6 Fresh deposits	May 26–July 6 Weathered deposits	July 6–Sept. 7 Fresh deposits	July 6–Sept. 7 Weathered deposits
1	1	4 lb.LA, 4 lb. Li., 3 lb. S., 4 oz. SF		39	31	58	54
	2	4 lb.LA, Bdx., 1 qt.MO	As_2O_3	(16.8)	(9.7)	(17.7)	(13.9)
	3-4	4 lb.LA, Bdx., 2 qt.MO	Cu.	(2.4)	(1.1)		
	5-7	3 lb.LA, Bdx.					
21	1	4 lb.LA, 4 lb. Li., 3 lb. S., 2 oz. YC					
	2	4 lb.LA, 2 lb. Li., 1 qt. MO, 8 oz. CSCP.		43	34		
	3-4	4 lb.LA, 2 lb. Li., 2 qt. MO. 8 oz. CSCP	As_2O_3	(13.5)	(8.5)		
	5	1-1/2 lb. DDT				99	87
	6-7	2 lb. DDT-Pyrax					
22	1	4 lb.LA, 3 lb. S., 4 oz. SF					
	2	4 lb.LA, 1 lb. ZS, 1 qt. MO	As_2O_3	41 (15.7)	31 (9.4)	discontinued	
	3-4	4 lb.LA, 1 lb. ZS, 2 qt. MO					
22a	5-7	4 lb.Cry.90, 2 qt.MO	Fluorine			80 (35.9)	66 (19.6)
22b	5-7	5 lb.Cry.70, 2 qt.MO	Fluorine			83 (39.6)	70 (24.7)
5	1	1 pt.Nic., 5 lb. KWK, 3 lb. S.					
	2-4	1 pt.Nic., 5 lb. KWK, 1 qt.SO.	Nicotine	85 (8.0)	60 (3.6)	92 (5.1)	78 (3.1)
	5-6	2/3 pt.Nic., 3.3 lb. KWK, 1 qt. SO					
	7	2/3 pt.Nic., 1 lb.KWK, 3 qt. MO					
5a	5	1-1/2 lb. DDT					
	6-7	2 lb. DDT-Pyrax				100	94

Table 2. (Continued)

Plot	Cover sprays	Materials per 100 gallons	Deposits[1]	May 26-July 6 Fresh deposits	May 26-July 6 Weathered deposits	July 6-Sept. 7 Fresh deposits	July 6-Sept. 7 Weathered deposits
15	1	1 pt.Nic., 5 lb. KWK, 3 lb. S.					
	2	1 pt.Nic., 5 lb. KWK, 1 qt.301 oil, 8 oz.CSCP	Nicotine	76 (8.0)	59 (2.7)	discontinued	
	3-4	1 pt.Nic., 5 lb. KWK, 2 qt.301 oil, 8 oz.CSCP.					
23	1	1 pt. Nic., 8 lb.X110, 3 lb. S, 2 oz. YC					
	2-4	1 pt. Nic., 8 lb.X110, 2 oz. YC	Nicotine	87 (4.9)	62 (2.4)	96 (4.2)	72 (2.1)
	5-7	2/3 pt.Nic., 5 lb. X110, 2 oz. YC					
24	1	1 pt.Nic., 8 lb. X110, 3 lb. S.					
	2	1 pt. Nic., 8 lb.X110, 1 qt. 301 oil					
	3-4	1 pt.Nic.,8 lb.X110, 2 qt. 301 oil	Nicotine	79 (6.2)	59 (2.2)	95 (5.3)	86 (2.5)
	5-7	2/3 pt.Nic., 5 lb.X110, 2 qt. 301 oil					
25	1	1 pt.Nic., 5 lb.X110, 3 lb. bentonite sulfur					
	2	1 pt.Nic., 8 lb.X110, 1 qt.301 oil, 8 oz.CSCP					
	3-4	1 pt.Nic., 8 lb.X110, 2 qt.301 oil, 8 oz.CSCP	Nicotine	87 (5.8)	63 (2.4)	95 (4.9)	79 (2.7)
	5-7	2/3 pt.Nic., 5 lb.X110, 2 qt.301 oil, 8 oz. CSCP					
26	1	1 pt.Nic., 8 lb.X110, 1 lb. F.					
	2	1 pt.Nic., 8 lb.X110, 1 qt.301 oil, 8 oz. CSCP, 1 lb. F.					
	3-4	1 pt.Nic., 8 lb.X110, 2 qt.301 oil,8 oz.CSCP, 1 lb. F.	Nicotine	82 (4.8)	65 (2.6)	94 (4.2)	87 (2.5)
	5-6	2/3 pt.Nic., 5 lb,X110, 2 qt.301 oil,8 oz.CSCP, 1 lb. F.					
	7	2/3 pt.Nic.,5 lb.X110, 2 qt.301 oil,8 oz.CSCP, 1/2 lb. F.					

Table 2. (Continued)

Plot	Cover sprays	Materials per 100 gallons	Deposit[1]	May 26-July 6 Fresh deposits	May 26-July 6 Weathered deposits	July 6-Sept. 7 Fresh deposits	July 6-Sept. 7 Weathered deposits
7	1	1 pt.Nic.,8 lb.X110, 3 lb. S.					
	2	1 pt.Nic.,8 lb.X110 1 qt.MO.	Nicotine	85 (5.6)	65 (2.5)	92 (4.5)	81 (2.0)
	3-4	1 pt.Nic., 8 lb.X110, 2 qt.MO.					
	5-7	2/3 pt.Nic.,5 lb.X110, 2 qt.MO.					
27	1	1 pt.Nic.,8 lb.X110, 3 lb.S.					
	2	1 pt.Nic.,8 lb.X110, 1 qt.MO.,1 lb.CBD	Nicotine	92 (5.6)	69 (2.2)	discontinued	
	3-4	1 pt.Nic.,8 lb.X110, 2 qt.MO.,1 lb. CBD, 4 oz. SF.	Cu.	(2.5)	(1.0)		
28	1	1 pt.Nic.,8 lb.X110,3 lb.S.					
	2	1 pt.Nic.,8 lb.X110, 1 qt.MO		94	71	100	94
	3-4	2 lb. DDT					
	5	1-1/2 lb.DDT					
	6-7	2 lb. DDT-Pyrax					
29	1	3 lb.MDM-1:5, 3 lb. S., 2 oz. YC					
	2	3 lb.MDM-1:5, 1 qt. MO, 6 oz.CSCP	Nicotine	86 (4.2)	65 (1.9)	94 (3.8)	85 (2.2)
	3-7	3 lb.MDM-1:5, 2 qt. MO, 4 oz.,CSCP.					
30	1	5 lb.MDM-1:10, 3 lb. S., 2 oz. YC					
	2	5 lb.MDM-1:10, 1 qt. MO., 6 oz. CSCP	Nicotine	84 (3.8)	68 (2.0)	97 (4.8)	86 (2.6)
	3-7	5 lb.MDM-1:10, 2 qt. MO, 6 oz. CSCP					

1/ Deposits as mmg. cm^2 are shown by figures in parenthesis.

In these tests the addition of the soybean phosphatides to the lead arsenate-lime mixture (21) decreased the deposits slightly below those of the standard lead arsenate-bordeaux plot but increased the efficiency. However, as a safener for lead arsenate, the lime was less effective than the bordeaux. About 30 percent defoliation occurred by June 30 on plot 21 compared to 10 percent on plot 1. Both treatments increased the amount of russet. The use of zinc sulfate without lime as a safener failed on plot 22, in which 70 percent of the fruit was russeted and 40 percent defoliation occurred before the end of June with some burn on all remaining leaves. The regular and 70 percent cryolites, used in the second-brood period on plot 22 (22a and b) proved equal in effectiveness, as they had in the laboratory. The larvicidal efficiencies, however, were significantly lower than those of the better nicotine bentonite formulas but well above those of the standard lead arsenate plot (1). The cryolites caused very little additional injury to the foliage on plot 22.

In this series of tests DDT was used on plot 28 in the last 5 of the 7 sprays and on plots 21a and 5a in the last 3 sprays. These tests demonstrate the high efficiency of the material, both when the deposits are fresh and after they have weathered. Because of the lower residual efficiency of the lead arsenate on plot 21 than of the nicotine on plot 5a, the use of DDT over lead arsenate deposits was less effective after periods of weathering than when used over nicotine. At harvest 26 days after the last spray there was no longer any significant difference, plot 21 having an efficiency of 86 percent, and 5a 89 percent. The efficiency at that time on plot 28 was 92 percent.

Treatments 5 and 15 were arranged to determine if a raw mineral oil could be used as a soybean oil substitute by including soybean phosphatides to smooth out the deposits. Although the deposits were well filmed the efficiency immediately after the early sprays was significantly lower where the new formula (15) was used. The ovicidal efficiency of the mineral oil combination was undoubtedly higher than that of the soybean mixture.

Treatment 23 was arranged as a test of a non-oil nicotine-bentonite schedule. It was as effective larvicidally as the standard Mississippi bentonite formula (7) immediately after the sprays but was less effective after weathering.

Treatment 24 in which a raw mineral oil was substituted for the emulsive type (7) was less effective early in the season probably because this oil produced more spotted deposits than the other. Later in the season after repeated applications brought about a smoother coverage it proved more effective than the "ready mix" oil.

The effect of adding soybean phosphatides to the raw oil formula is illustrated by treatment 25. As anticipated it gave very smooth and more effective but lighter deposits early in the season. Thereafter the weathered deposits on plot 25 were less effective than those on 24. The use of No. 25 in the first-brood period and No. 24 thereafter should prove advantageous.

The effect of adding ferric dimethyl dithiocarbamate to the No. 25 formula was to reduce the weight and effectiveness of fresh deposits but to increase the effectiveness of the weathered deposits. Incidentally, in this formula the fungicide took the place of zinc sulfate and gave the mixture marked deposit building properties on the side of the fruit and foliage facing the spray gun. Both the fungicide and nicotine built up readily when the surfaces were oversprayed leaving a heavy coal-black film. Deliberate over-spraying was restricted to only a few branches which were avoided when the regular samples were taken.

On plot 27 the cupric benzoate dihydrate previously mentioned gave as promising results in these first brood laboratory-field tests as it had in the laboratory experiments. However, early in July some foliage yellowed and dropped.

The results obtained with treatments 29 and 30 proved that the micronized 1:10 nicotine bentonite mixture was no more effective than the 1:5 mixture. Previous tests had shown that the regular 1:10 mixture was considerably more effective than the regular 1:5 product probably because of the larger particle size of the latter.

Among the nicotine treatments in this series of tests Nos. 5 and 26 were the only ones leaving objectionable residues after the fruit was brushed at harvest.

Foliage on all the DDT sprayed trees began dropping in August and defoliation was well advanced by late September but since there was a much heavier European red mite population on these trees earlier in the season than on other trees, including those left un-sprayed, the real cause of the injury and defoliation was not definitely established. No injury developed where DDT was used in other tests on Winesap although it allowed the mite population to increase on that variety also. The increased mite population on trees sprayed with DDT is believed to have been due to the injurious effect of this insecticide upon the predators of the mite.

In ovicidal tests conducted under field conditions, DDT deposits, producing larvicidal efficiencies of 96 to 100 percent, had no significant effect on 2,472 eggs. The number of eggs deposited by caged moths on foliage in these plots was about half that deposited by moths confined in certain other plots, but ants attacked the moths in some cages and no certain evidence was obtained that the compound would reduce oviposition.

In preliminary laboratory tests in which caged moths were sprayed with DDT (1 lb. per 100 gals.) the compound appeared to have a slight toxicity to the adult when a wetting agent was included. However, 66 percent of the moths remained normal for 24 hours after the application as compared to 86 percent for those sprayed with the lead arsenate check and 18 percent for those sprayed with nicotine bentonite (1/2 pt. nicotine sulfate, 4 lb. bentonite, 2 oz. soybean phosphatide). When moths were confined in glass containers coated either with DDT deposited from an acetone solution or with a micronized talc-DDT dust, 100 percent mortality occurred within 24 hours. It seems likely therefore that foliage and fruit deposits heavy enough to kill most of the larvae would have some toxicity to the moths.

Series 3

In a third series of laboratory-field tests on Winesap, four cover sprays were applied between June 25 and harvest. DDT at 1 pound per 100 gallons gave slightly better results when used alone than when supplemented either with 2 quarts of mineral oil and 1 pound of Mississippi bentonite per 100 gallons, or with a 1/2:1:100 bordeaux mixture. During the month after the final spray rainfall totalled 2.45 inches. The efficiency of DDT alone declined from 100 percent to 88.8, that of DDT-oil from 100 to 86.5 and that of DDT-bordeaux from 99.6 to 77.9.

Field Tests of Insecticides on Randomized Plots

Rome Beauty

Infestation data representing all drops and picked fruit on the 14 treatments (7 single tree replicates) listed in table 1 are summarized in table 3.

These plots were arranged in a 11 x 17 row block with the trees set 40' x 40'. Two of the 11 rows near the middle of the block were of the Turley variety. A separate series of 6 plots replicated 5 times was set up on the Turleys and the results are discussed separately.

Twenty bait traps distributed in trees sprayed by the grower along 2 sides of the area captured more than 9,000 moths during the season. The infestation on these Rome Beauty trees in 1942 averaged 80 injuries per 100 apples despite the use of a heavy lead arsenate program.

Table 3. Results of Small Plot Tests on Rome Beauty. Vincennes, Indiana 1943

Plot (for details of treatments see Table 1.)	Average per tree--June 30 Worms	Average per tree--June 30 Stings	Seasonal Data: Apples per tree	Seasonal Data: Clean Apples	Seasonal Data: Per 100 Apples Worms	Seasonal Data: Per 100 Apples Stings
	number	number	number	percent	number	number
1. Standard lead arsenate-oil-bdx.	66	220	4,567	68.6	21.3	29.1
2. Lead ars., oil, bdx., and soybean phosphatides	29	119	4,344	74.7	14.6	26.7
3. Lead arsenate, phenothiazine, zn. sulfate and lime	30	75	3,858	65.9	26.4	26.8
4. FPNB-MO	13	57	3,628	82.2	13.6	6.7
5. Std. tank mix Nic., KWK, Soyoil	6	56	3,817	83.9	12.9	5.4
6. Tank mix Nic., KWK, MO in 4 sprays, FPNB-MO later.	33	77	3,407	83.5	13.1	5.5
7. Tank mix Miss. bentonite (X110), Nic., MO	6	50	3,887	88.4	9.5	3.3
8. No. 7 + F.	10	68	4,174	83.1	14.4	4.5
9. Reduced Nic. X110, MO, ZS	39	66	3,741	82.6	15.6	4.4
10. No. 9 + SCP.	71	82	4,197	78.8	19.0	5.6
11. Tank mix Miss. bent. (PC), Nic., MO	23	68	4,481	87.0	10.9	3.6
12. Reduced Nic., PC, MO, ZS, SCP	82	100	4,302	78.5	19.7	5.3
13. MDM-1:5, 301 oil, SCP.	17	86	3,886	90.8	7.2	2.7
14. DM-1:10, 301 oil, SCP.	64	49	3,529	81.0	16.6	4.6
Least significant difference, 19:1 odds	47	81	880	5.6	5.3	4.1

To properly compare the treatments given in table 3 consideration should be given to the larvicidal data of table 1, the adverse effect of spray drift from lead arsenate plots onto nicotine plots and the fact that inter plot migration of moths reduced potential differences, particularly between plots where the control of the first brood differed greatly. The value of those nicotine treatments most toxic to moths were underestimated by both larvicidal efficiency and field-plot control data.

In this set-up two localized areas of very intensive codling moth attack developed. One, extending from the north center to the center of the block was large enough to affect an approximately equal number of replicates of each plot. The other, however, was at the southwest corner and extended into only part of the 7th replication. Replicates of plots 2, 10, and 12 were located in the outer row. The seventh tree of plot 10 contained nearly as many worms on June 30 as were found in the other 6, while the plot 2 and 12 trees contained 1/3 of their plot totals. The seventh replicate of the other 11 plots differed only slightly from the respective plot averages. The seasonal data indicated that while plots 2, 10, and 12 were still affected the most the infestations on the 7th replications of plots 3, 5, 7, 9, and 13 had also increased to a point well above their respective plot averages. These replicates were within 4 rows of the boundary. Those of the other plots farther away were unaffected.

In the control of the first-brood worm entrances, treatments 5 and 7 may be considered outstanding with 4, 8, 11, and 13 grouped in second place, 2, 3, 6, and 9 in third, and 1, 10, 12, and 14 last.

The outstanding treatment from the standpoint of both seasonal and first-brood performance as well as practicability was the tank mix Mississippi bentonite (X110) formula (7). Although the micronized dry mix (13) gave better results, its weakness early in the season would have to be overcome by the use of more nicotine and its production at present is impracticable. Probably the other tank mix Mississippi bentonite formula (11) could be classed with treatments 7 and 13 in effectiveness.

The other nicotine treatments all gave about equal results when the seasonal data are considered and allowance is made for the population distribution in the seventh replication. However, unless the first-brood control shown by the reduced nicotine treatments (9, 10, 12 and 14) was improved by using more nicotine bentonite in at least the first two sprays these formulas might fail in large scale use.

It is of particular interest to note that number 9, with one half as much nicotine bentonite in first-brood sprays as 7 and 3/4 as much later, proved equal to the factory-processed material yet its cost averaged $1.15 per tree less. The cost of treatment 7 was $0.35 per tree less than that of 4 (costs based on ceiling prices). Inclusion of ferric dimethyl dithiocarbamate in the tank-mix Mississippi bentonite formula apparently reduced its effectiveness to the level of the old Wyoming bentonite, nicotine sulfate, soybean oil mixture.

The deposit building mixtures (10 and 12) require further study. Their performance was somewhat erratic from spray to spray because the order and method of mixing was varied several times in attempts to improve performance. Best results were obtained when the soybean phosphatides were stirred into the oil rather than into a water slurry and when the zinc sulfate was added last to the full tank.

Partly because seasonal conditions were unfavorable to lead arsenate, treatments 1, 2 and 3 gave very poor results. However, the addition of the soybean phosphatide spreader to the standard lead arsenate-bordeaux treatment resulted in an increased profit of approximately $1.50 per tree after deducting the extra cost. This formula resulted in a very smooth even film and avoided the uneven coloring on Rome Beauty caused by the standard treatment.

The cover spray materials used on plot 1 cost $1.20 per tree while those on plot 7 cost $2.55. Since the average yield on these plots was more than 20 bushels per tree the cost of washing the lead arsenate sprayed fruit used up most of the saving. The net gain in profit (September prices) realized from the use of treatment 7 in comparison with treatment 1 amounted to not less than $5.00 per tree.

A moderate amount of arsenical injury developed on the three lead arsenate plots, and the leaf hopper population was much greater than where nicotine was used, however, the weak bordeaux and phenothiazine effectively prevented late scab infection on foliage. Much of this developed on all the nicotine plots except that which had received ferric dimethyl dithiocarbamate (8). Very little developed on the fruit.

Objectionable bentonite residues remained on fruit from plot 5 after brushing. That from all other nicotine plots was easily removed by the brush machine, however, the ferric dimethyl dithiocarbamate resulted in a deeper green ground color but had no effect on the red. The foliage on those nicotine plots on which zinc sulfate was used (9, 10 and 12) developed a paler green and color development on the fruit was somewhat retarded.

The Mississippi bentonite X110, nicotine, mineral oil formula was used successfully in 1943 on blocks of 10 to 45 acres by several growers who had not been getting satisfactory results with lead arsenate. A 45 acre block near Henderson, Kentucky in which it was used produced 90-95 percent clean fruit. The formula will be used extensively by growers in 1944.

Turley:

The results of tests on this variety are given in table 4. This is an apple of the Winesap group, its size averaging 50 percent greater than that of Rome Beauty. Possibly because of its size and generally smaller number of apples per tree along with its earlier ripening date (between Jonathan and Rome Beauty) it is very difficult to protect against third-brood larvae. In these experiments the final worm population ranged from 15 to 30 times greater than it was on June 30 despite the application of 5 sprays totalling 150 gallons per tree in July and August.

These treatments rank in effectiveness in the order of their listing. The results with the split schedule (15) of a Wyoming bentonite tank mix in which soybean phosphatides were used with a raw mineral oil in the first brood period followed by a Mississippi bentonite-nicotine formula in which a heavier and cheap raw oil was used were outstanding. The visible harvest residues were removed satisfactorily by brushing but the fruit was left slightly greasy.

Plots 16, 17, and 18 were set up to compare the effectiveness of a raw mineral oil, soybean oil, and an emulsive type summer oil when used with the Panther Creek bentonite and nicotine. The raw mineral oil at 2 quarts per 100 gallons was definitely superior to soybean oil at 1 quart and the summer oil at 2 quarts of the three, however, the soybean oil gave the least spotted type of coverage.

As in previous years when other nicotine bentonite formulas were used with or after lead arsenate the results proved to be but little better than obtained with the full lead arsenate program of nicotine bentonite. This will be seen by comparing plots 18, 19, and 20.

Table 4. Results of Small Plot Field Tests on Turley. Vincennes, Indiana. 1943

Plot	Cover spray1/	Materials per 100 gallons	Average per tree June 25		Seasonal Data 2/			
			Worms	Stings	Apples per tree	Clean Apples	Per 100 Apples Worms	Per 100 Apples Stings
			(No.)	(No.)	(No.)	(%)	(No.)	(No.)
15	1	1 pt.Nic.,5 lb.KWK, 3 lb. S.						
	2	1 pt.Nic.,5 lb.KWK, 1 qt. 301 oil, 8 oz. SCP	6	26	2,063	89.0	6.6	5.6
	3-4	1 pt.Nic.,5 lb.KWK, 2 qt.301 oil,8 oz.SCP						
	5-9	2/3 pt.Nic.,5 lb.PC, 2 qt. 371 oil						
16	1	1 pt.Nic.,8 lb.PC, 3 lb. S.						
	2	1 pt.Nic.,8 lb.PC, 1 qt. 301 oil	7	27	1,630	87.3	9.8	4.6
	3-4	1 pt.Nic.,8 lb.PC, 2 qt. 301 oil						
	5-9	2/3 pt.Nic.,5 lb.PC, 2 qt. 301 oil						
17	1	1 pt.Nic.,8 lb.PC, 3 lb. S.						
	2-4	1 pt.Nic.,8 lb.PC, 1 qt.SO	16	61	2,277	76.8	20.2	8.6
	5-9	2/3 pt.Nic.,5 lb.PC, 1 qt. SO						
18	1	1 pt.Nic.,8 lb.PC,3 lb.S.						
	2	1 pt.Nic.,8 lb.PC, 1 qt. MO	26	39	2,108	76.6	19.6	8.3
	3-4	1 pt.Nic.,8 lb.PC, 2 qt. MO						
	5-9	2/3 pt.Nic.,5 lb.PC, 2 qt. MO						
19	1	4 lb.LA,4 lb.Li.,3 lb. S.,4 oz. SF						
	2	4 lb.LA, Bdx.,1 qt.MO	17	60	1,876	63.8	23.3	29.7
	3-4	2 lb.LA,2 qt.MO,2/3 pt. Nic.,5 lb.PC,8 oz.ZS.						
	5-9	2/3 pt.Nic.,5 lb.PC, 2 qt. MO.						

Table 4. (Continued)

Plot	Cover sprays1/	Materials per 100 gallons	Average per tree June 25 Worms (No.)	Average per tree June 25 Stings (No.)	Seasonal Data2/ Apples per tree (No.)	Clean Apples (%)	Per 100 Apples Worms (No.)	Per 100 Apples Stings (No.)
20	1	4 lb.LA,4 lb.Li.,3 lb. S.,4 oz. SF.						
	2	4 lb.LA,Bdx.,1 qt.MO.	21	79	2,038	61.3	30.7	48.8
	3-4	4 lb.LA,Bdx.,2 qt.MO.						
	5-8	3 lb.LA,Bdx.						
	9	2 lb.LA,Bdx.						
Least significant difference, odds 19:1			21	43	734	9.6	13.2	34.2

1/ Cover sprays were applied on 5/21, 28, 6/7, 6/16, 7/3, 16, 8/3, 17 and 30.

2/ Representing all drops and picks.

Test of Phenoxathiin on Rome Beauty and Turley:

Two of the Turley trees adjacent to each other and 2 nearby Rome Beauty trees were too small to include in the regular experiments. One of each variety was therefore sprayed the same as plot 20 with the standard lead arsenate program. The other two were sprayed on the same dates with 8 pounds of a 50:50 Phenoxathiin-pyrophyllite mixture per 100 gallons. The results follow:

	Lead Arsenate	Phenoxathiin
Number of apples per tree	1,300	1,000
Percent clean apples	63	25
Number of worms per 100 apples	26	144
Number of stings per 100 apples	40	18

Almost the entire infestation on the Turley tree sprayed with phenoxathiin developed after June 28. On that date there were only 4 injuries per 100 apples. By August 6 the injuries (mostly worms) had increased to 134 and by harvest to 178.

Indications were that the material acted partly as a repellent to moths early in the season but thereafter during the hot weather it did not remain long enough to be of any value.

Ben Davis

In the tests on Turley the Panther Creek Mississippi bentonite was used. As a test of the use of soybean oil with the X110 Mississippi bentonite in comparison with lead arsenate under a very heavy infestation near an unsealed packing house, 20 mature Ben Davis trees were arranged in pairs, one of each being sprayed with the standard lead arsenate-bordeaux-oil program and the other the same as plot 17, table 4, except for the brand of bentonite used. The results were as follows:

	Lead Arsenate Bdx. MO.	TM-Nic., X110 bent., soybean oil
First brood injuries per tree (June 29).......		
Number of worms	105	70
Number of stings	661	327
Number of apples per tree	1,711	1,593
Percent clean apples (whole crop)	42.1	67.7
Percent clean apples (picked fruit)	37.3	67.2
Injuries per 100 apples (whole crop)		
Number of worms	56.6	22.2
Number of stings	111.0	26.5
Percent wormy apples having calyx entrances ..	6.5	30.1

Differences in the performance of the X110-soybean oil formula and lead arsenate were much greater than between the Panther Creek-soybean oil (17) and lead arsenate (20) on the Turley variety despite the use of 1/2 percent oil with the lead arsenate in the fifth cover on Ben Davis and the use of an extra pound of lead arsenate in the fifth and ninth covers. The fifth cover was applied June 24 at the peak of hatch following heavy emergence from the shed. Eight of the 10 trees in the lead arsenate plot were also given an extra lead arsenate curculio spray 7 days after petal fall. This was omitted from 8 of the trees in the nicotine plot.

Winesap

Near the peak of second-brood hatch, small plot field tests were started in a well-sprayed commercial orchard where the grower's lead arsenate program had failed to give satisfactory control in previous years and was again failing. In spite of the application by mid-July of 6 complete cover and 2 top-off sprays with 3.2 to 4 pounds of lead arsenate per 100 gallons supplemented with nicotine sulfate and with mineral oil in several of the covers, 4,000 apples examined on 20 mature Winesap trees on July 21 averaged 15 worm entrances and 34 stings per 100.

Five plots were arranged in a restricted randomization with 4 single-tree replicates in each. All drops were removed on July 21, and the experimental sprays were applied on July 22, August 12, and 28. The treatments and results are given in table 5. Drops which fell after July 21 are included.

The average crop per tree was from 2,870 to 3,180 apples in the different plots. At harvest on October 2, from 40 to 44 percent of the crop had dropped in the lead arsenate and nicotine plots but only 25 to 32 percent in the DDT plots. Not only did the DDT at 1-1/2 pounds (plot 5) completely stop worm entrances, but there were no new stings at harvest and less than 3 percent of the picked fruit was wormy. The presence of many hatched eggs on fruit in this plot is evidence that the complete control of worm entrances did not result from the avoidance by ovipositing moths of trees sprayed with DDT. Many new injuries were observed on the lead arsenate and nicotine plots and 25 percent of the picked fruit on plot 3 contained successful worm entrances, in spite of adequate coverages as shown by analyses made by the Division of Insecticide Investigations.

Table 5. Results of Small-Plot Field Tests with DDT, Lead Arsenate, and Nicotine Bentonite. Vincennes, Indiana. 1943

Plot No.	Treatment (Quantities per 100 gallons)	Percent Clean Apples	Number per 100 Apples: Worms	Number per 100 Apples: Stings	Percent increase in Worm entrances After July 21
1	Tank-mix nicotine bentonite 1/	23	107	81	664
2	Lead arsenate, 3 lb. 2/ August 28 spray omitted	26	109	96	623
3	Same as 2, except Aug. 28 spray included	31	85	104	435
4	DDT, .75 lb. 3/	54	31	51	103
5	DDT, 1.5 lb. 3/	59	12	56	-21
Least significant difference, Odds 19:1		21	62	41	

1/ Nicotine sulfate (40%), 0.67 pint; Mississippi bentonite, 5 lb.; soybean phosphatide spreader, 2 ounces.

2/ With copper sulfate, 0.5 lb., lime, 1 lb.

3/ Mixed with an equal quantity of Pyrophyllite.

Experiments with Moth Poisons

Work on this phase of codling moth control has been conducted in a limited way for several years. In detailed feeding experiments early in 1943, 164 female moths from which water was withheld deposited only 189 eggs while 178 which had access to water laid 2,077. Lack of water proved as harmful to female moths as their feeding on a 1-800 nicotine sulfate solution, or tank-mix nicotine bentonite. Unpoisoned moths consumed the equivalent of their body weight (24 mg.) of distilled water during their average life span of 13 days. Of various dilutions of nicotine sulfate and water, 1-1200 or even 1-1600 mixtures appeared sufficiently toxic for use in field tests. Experiments with various supplements such as acetic acid, certain essential oils used in baits, or sugar gave erratic results and proved that certain factors not yet discovered have a very strong influence on the response of moths to various solutions. Wet tank-mix nicotine bentonite residues from which the soluble nicotine had been removed proved highly toxic to female moths. They readily took up water from the residues and after regurgitating and reingesting the liquid a few times they became paralyzed. In so far as could be determined they consumed no solids. Nicotine bentonite residues on foliage are probably more toxic to moths than has been heretofore realized.

A control test somewhat similar to that reported in 1942 was arranged in an 18 acre Golden Delicious orchard, 8 rows wide and 100 long. This orchard was sprayed uniformly by the grower, who used a full program of lead arsenate and lime with mineral oil in certain sprays.

The tests were carried on in 4 blocks, each 8 x 20 rows. Immediately after sunset on 32 days during the season a 1-200 solution of nicotine sulfate was applied as a coarse spray to the tops of the trees in second and fourth blocks, each 3.6 acres, the others being left as checks. The truck-mounted sprayer was driven at sufficiently reduced speed so that two rows could be sprayed from the top of the tank by one sprayman who applied approximately 2/3 to 3/4 gallon per tree.

The spraying was completed within a 20 minute period before moth activity reached its peak and late enough to prevent evaporation of the droplets before the moths could feed.

Infestation data were secured by examining stratified samples of 200 apples on each of 8 well distributed trees in each block. An unsealed packing shed was located at the junction of the second (treated) and the third (untreated) blocks. Prevailing winds blew

across the short dimension of the orchard. Observations late in June at the peak of hatch (for larvae from packing shed moths) indicated that the moths from the shed spread out across the treated and untreated blocks adjoining it into the treated and untreated replicates 21 to 40 rows beyond with more moving to the southeast into adjacent treated block than to the northwest. The initial population as indicated by 10 traps in each block appeared equal prior to May 20. Eleven applications were made between May 17 and June 2, 12 between July 14 and August 6, and 9 between August 11 and 31. Other work prevented the application of sprays in June during the heavy emergence from the shed. While it was occurring trap catches in the adjacent treated replicate were 20 percent greater than in the adjacent untreated. Again in September the moth population leveled off and September catches were equal.

Infestation data follow:

Date of Examination	Treatment	Clean apples Percent	Worms and stings per 100 apples: Number Worms	Number injuries	Percentage difference in injuries
July 5	Check	66.1	13	68	
	Sprayed	76.6	9	45	-34
July 31	Check	48.9	31	137	
	Sprayed	60.4	19	86	-37
Sept. 9	Check	20.7	120	314	
	Sprayed	37.8	65	182	-42

The cost per tree for all materials and labor (60¢ per hour) was less than 30¢. The average yield exceeded 10 bushels of picked fruit. At a price differential of $1.50 per bushel for clean and wormy fruit the sprays yielded a net gain of more than $2.00 per tree despite the adverse conditions under which the experiments were operated.

Reasons for the slow increase in the differences between the treatments after July 5 were (1) the grower had a large crew work 2 weeks in July and again 2 weeks in August removing wormy apples throughout the orchard (2) as the infestation neared the saturation point in the untreated area movement of moths into the treated area increased (3) the nicotine spray may have attracted moths into the treated areas and (4) drop fruit could not be included in the examinations yet "worminess" was the main factor responsible for the drop which occurred prior to September 9. Bait trap catches differed most between the blocks during the periods when these nicotine sulfate

sprays were applied. The average numbers of moths captured per trap, with 20 traps per treatment, are shown below for different parts of the season.

	May 20	May 21-June 6	June 7-July 14.	July 15-Aug. 30.	Aug. 31-Sept. 28.
Check	12.1	41.3	20.6	150.5	103.7
Sprayed	13.0	29.2	24.5	80.8	104.1
No. of dusk sprays applied	1	10	0	21	0

One tree in each block was fumigated 15 times during the season. The total number of moths knocked down on canvases averaged 56 per tree for the sprayed and 117 for the check blocks. Male moths outnumbered females by 46 percent in the sprayed area and 11 percent in the unsprayed area.

The effects of the sprays were checked on 3 occasions by spreading canvases under the trees and collecting the poisoned moths during the hour following the application and again early next morning. The trees were then fumigated and the remaining moths obtained. The records follow:

Date	No. trees used	No. moths downed by sprays		No. moths downed by fumigation		Percent of moth population killed by sprays	
		♂♂	♀♀	♂♂	♀♀	♂♂	♀♀
July 20	5	0	7	3	3	0	70
Aug. 20	5	7	29	20	11	26	65
Aug. 26	3	3	9	5	2	38	82

The females were definitely more attracted to the poison spray than the males. Some loss of paralyzed or dead moths to ants, spiders or other predators undoubtedly occurred before the early morning collection. Very few moths came down during the hour after spraying except on August 20 when 11 of the 36 were taken in the evening. The

delay was believed caused by the quiet conditions that usually existed, there being very little leaf movement to dislodge paralyzed moths that did not fall free. By completing the count in the morning, moths that were only partially paralyzed were given a chance to recover enough to leave the canvas. Females of all ages were poisoned and all contained eggs, but their average egg content appeared less than that of those taken from traps.

The results obtained by the application of poison sprays at dusk suggest that as much of a kill can be obtained in this manner with less than 1 gallon of spray per tree as can be obtained by spraying during the day with 20-30 gallons of nicotine sulfate solution intended to kill by contact, particularly if the latter sprays are applied in a manner that allows some moths to escape to other trees.

Investigations of bait traps

A total of 168 traps were operated in 6 locations, the standard double quart jar trap being used in most of the tests. Two series of 48 and 50 traps were used to compare the relative attractiveness of different baits. Other traps were used for timing sprays, for obtaining population data and for testing the attraction of the sexes to each other.

Attractiveness of males or females to the opposite sex

Odd numbered traps in a series of 20, rotated twice weekly through 20 trees, were baited with virgin female moths in addition to the standard brown sugar, oil of sassafras, sodium arsenite formula used in all 20. The females were confined, usually in pairs, in 1 x 1/2 inch cylindrical screen cages attached in an upright position to the tops of the 3-mesh screen cover. A cork in the upper end of the cages provided shade for the moths, which were replaced as they died.

In one test male moths were definitely attracted into the traps because of the presence of virgin females and the catch of female moths was also increased. A second test later in the season indicated that males are also attracted to females that have mated but to a lesser extent than to virgin females. Here again the catch of females was also increased. In other experiments male moths did not prove attractive to females nor did the crushed abdomens of either sex attract the other. The sex attraction of the females to males ceased when the former died. The results raise the question as to the influence an emergence cage in an orchard may have on the sex ratio of the native population at various distances from it and the effect that this in turn may have on the fertility of eggs deposited at different distances from the cage. An emergence cage in which 1,250 moths emerged during May and June was located in the top of a tree at the center of the localized heavy infestation adjacent to

plots 2 and 12 in the 7th replication of the small plot field tests previously discussed. Although very few moths escaped, the crop on this tree was almost a total loss and that on adjacent trees was severely injured, as already noted.

Tests of different baits

In a series of 5 test baits, each replicated 10 times, various mixtures of No. 13 soft sugar supplemented with apple syrup or apple esters were all less than 50 percent as effective as the standard bait of 10 percent No. 13 soft sugar in water plus 1/2 cc. natural oil of sassafras and 1/2 gm. sodium arsenite per quart. Solutions containing .01 to .04 percent apple esters (in water) failed to capture any moths. All of these baits except the standard were replaced by others on July 1. One gallon wide mouth glass jars with openings 1-1/2" larger in diameter than the standard trap were tested as bait containers. They caught only 57 percent as many moths as the standard double quart jar trap. A mixture of an 8 percent sugar solution, and 2 percent apple syrup with 2 to 4 gm. sodium arsenite per gallon caught an average of 277 moths per trap as compared to 405 for the standard bait.

BELTSVILLE, MARYLAND

E. H. Siegler, In Charge

The evaluating of individual compounds and mixtures for possible use as insecticides against newly hatched codling moth larvae was continued in the laboratory during 1943 by means of the apple plug method, using in each test approximately 100 plugs each of which was infested with one ready-to-hatch codling moth egg. Foliage tests to determine tolerance were also conducted.

Synthetic Organic Compounds

Toxicity tests of DDT

The most promising synthetic organic compound tested was DDT. The more important results of initial toxicity tests (plugs infested same day spray was applied) of DDT alone and combined with certain fungicides and wetting agents are given on the following page.

Materials per 100 gallons	Percentage apple plugs Wormy	Stung
DDT - 4 lb.*	1	1
DDT - 3 lb.*	1	3
DDT - 2 lb.*	3	6
DDT - 1 lb.	16	12
DDT - 1/2 lb.	15	2
DDT - 1/4 lb.	22	11
DDT - 2 lb., lime sulfur 1 gal.	20	27
DDT - 2 lb., hydrated lime 6 lb., wettable sulfur 6 lb.	14	9
DDT - 2 lb., bentonite 8 lb.	23	7
DDT - 2 lb., neutral fish oil soap 1/4 lb.	7	21
DDT - 2 lb., Bordeaux (4-8-100)	2	7

* 2 Tests.

The addition of lime sulfur, of hydrated lime plus wettable sulfur, and of bentonite reduced the effectiveness of DDT as did neutral fish oil soap but to a lesser extent. Bordeaux mixture, on the other hand, apparently was compatible with DDT from the standpoint of toxicity.

Fortunately, DDT is a comparatively non-volatile compound, and this characteristic was demonstrated by the results obtained in some residual tests in which apple plugs were infested several days after application of the insecticide. Some typical results are shown below.

Materials per 100 gallons	Number days from spraying to infesting	Percentage apple plugs Wormy	Stung
DDT - 4 lb.	5	0	3
DDT - 4 lb.	6	5	5
DDT - 3 lb.	4	2	0
DDT - 3 lb., diglycol stearate 2 oz.	4	1	0
DDT - 3 lb., pyrophyllite 6 lb.	4	3	0
DDT - 3 lb., hydrated lime 6 lb.	6	4	18
DDT - 2 lb.	6	11	2

DDT is not pure 2,2-bis(parachlorophenyl)-1,1,1-trichloroethane, and, in order to determine the toxicity of its other components, fractions were prepared by the Division of Insecticide Investigations. The crystals obtained from the mother liquor of DDT exhibited considerable toxicity.

DDT apparently kills codling moth larvae by contact action. In view of this the question arose as to whether or not DDT would be effective should it become covered with dust such as is normally deposited on the host plant under field conditions. An experiment was made in which DDT (2-100) was first sprayed on the apple plugs, followed by 6 applications of pyrophyllite (8-100) each spray being allowed to dry between successive applications. Despite this heavy treatment with pyrophyllite on top of DDT there were no wormy apple plugs and only 5 percent were stung. This experiment does not establish the method of kill since mortality could have occurred solely through contact action as the larvae mechanically disturbed the spray material or partly by contact effect combined with stomach-poison action. Although it does not seem so probable, some larvae may have died as a result of stomach-poison action alone.

Action of DDT on newly hatched codling moth larvae.

To determine the effect of DDT on newly hatched codling moth larvae, glass plates were sprayed with the insecticide at a dosage of 2 pounds per 100 gallons. For comparative purposes glass plates also were sprayed with lead arsenate (2-100) and unsprayed plates were used for checks. After the spray had thoroughly dried, larvae were transferred to the plates and after being exposed to contact with DDT for periods of from 1 to 15 minutes they were transferred to apple plugs. The results of these tests, which are given on the next page, show that DDT is very effective in destroying newly-hatched larvae exposed under such conditions.

Spray Materials	Number of tests	Exposure time in minutes	Number of larvae	Average percentage survivals
DDT	3	15	60	0
Lead arsenate	3	15	60	77
Check	3	15	58	71
DDT	3	10	20	0
Lead arsenate	3	10	19	42
Check	2	10	9	22
DDT	3	5	15	0
Lead arsenate	3	5	15	80
Check	2	5	10	80
DDT	2	2	20	10
Lead arsenate	2	2	20	45
Check	2	2	19	58
DDT	2	1	20	0
Lead arsenate	2	1	20	85
Check	2	1	19	58

In another series of tests, glass plates were sprayed with DDT alone (2-100), and also with DDT (2-100) followed by 6 applications of pyrophyllite (8-100). Between the application of DDT and successive applications of pyrophyllite the sprays were allowed to dry. The results show that DDT was very effective against newly hatched larvae exposed for 30 minutes in spite of the coating of pyrophyllite. It is believed that the crawling of the larvae on the sprayed surface disturbed the coating sufficiently to permit bodily contact with the DDT.

Spray Materials	Number of tests	Exposure time in minutes	Number of larvae	Average percentage survivals
DDT	1	30	50	0
DDT covered with pyrophyllite	1	30	50	2
DDT	2	15	24	0
DDT covered with pyrophyllite	2	15	25	0

The results of a few preliminary tests indicate that under certain conditions DDT may possess ovicidal value.

The results of limited tests in which newly emerged codling moth adults were confined in small paraffin-paper cages which had been sprayed with DDT (2-100) indicate that it is somewhat effective against codling moth adults under these conditions of confinement. Its action, however, did not appear to be rapid. As shown by the detailed data given below egg deposition occurred in some of the check cages but none in those sprayed with DDT.

Cage No.		Mortality after confinement First day	Second day	Third day	Fourth day	Fifth day	Number of eggs laid
1	Sprayed with DDT	2	3	4	4	5	0
2	Do	1	3	4	4	5	0
3	Do	0	3	4	5	-	0
4	Do	1	2	4	5	-	0
5	Do	0	3	5	-	-	0
1	Unsprayed check	0	0	0	0	0	0
2	Do	0	0	0	0	0	0
3	Do	0	0	0	0	0	6
4	Do	0	0	0	0	1	62
5	Do	0	0	0	0	3	77

Preliminary laboratory tests with potted Delicious apple trees seemed to indicate that DDT, especially with lighter dosages such as might be employed under field conditions, would not injure apple foliage.

The results of small-scale field tests with sprays of DDT and lead arsenate applied during May against foliage of apple, peach, and grape are shown on the following page.

Materials per 100 gallons		Injury to foliage: Rome apple	Injury to foliage: Elberta peach
DDT 5% + diluent and wetting agent 95%	8 lb.	None	None
Do	20 lb.	Do	Do
Do	30 lb.	Do	Do
Do	40 lb.	Do	Do
Do	50 lb.	Do	Do
DDT 4 lb., pyrophyllite 4 lb. (2 tests)		Do	Slight to moderate
DDT 3 lb., Bordeaux mixture (4-8-100)		Moderate	
DDT 3 lb., wettable sulfur 6 lb., hydrated lime 6 lb.		None	None
Lead arsenate 4 lb., hydrated lime 4 lb.		Do	Moderate
Lead arsenate 4 lb., calcium oxide 3 lb.		Do	Severe

	Concord grape
DDT 4 lb.	Severe
Lead arsenate 4 lb.	None

The amount of wetting agent contained in the first mixture tested is apparently too great for satisfactory use against the codling moth. The run-off was so excessive that but little spray material remained on the foliage even when used at the dosage of 50 pounds per 100 gallons.

Tests of miscellaneous synthetic organic compounds.

The following synthetic organic compounds gave unpromising results in view of 83 to 99 percent wormy apple plugs:

2-Nitrodibenzofuran

Dibenzofuran

Cyclohexylphthalate

2-Furfuryl acetate

7-nitro-1,2,3,4-tetrahydrobenzofuran

Beta-naphthoylacetonitrile

1,2,3,4-tetrahydrodibenzofuran

Phenylphthalate

Benzoic acid

Naphthalene

O-cyclohexylphenol

5,6,7,8-tetrahydro-1-naphthylamine

N-(2-benzoxazolyl)aniline

Tetrahydro-2 furfuryl acetate

1-Naphthylamine

Bromocyclohexane

Bromobenzene

Beta-tetrahydronaphoylacetonitrile

N-(2-benzoxazolyl) cyclohexylamine

Tetralin

Cyclohexane carboxylic acid

O-phenylphenol

Several tests with phenothiazine, used at the rate of 4 pounds per 100 gallons, showed no difference in toxicity of material micronized in 1942 as compared with that micronized in 1943. Sublimed phenothiazine showed greater toxicity than the regular micronized product, but there was no significant difference in effectiveness between the sublimed material and the sublimed material micronized and used with an anti-oxidant added.

Larval Feeding Attractants

The Eastern Regional Research Laboratory at Philadelphia, Pennsylvania submitted apple esters to be tested for their value as possible larval attractants. The results indicated that the esters used in sprays at the rate of 5 percent by volume in water plus preservative or in 6 percent ethanol did not increase the effectiveness of lead arsenate used at the rate of 4 pounds per 100 gallons.

Naturally Occurring Organic Compounds

Extractives from various plant materials were tested against newly hatched larvae at dosages equivalent to 4 pounds of extractive per 100 gallons, the usual solvents such as ethanol, ether, petroleum ether, chloroform and combinations of these being used. The three most toxic extractives were:

(1) Ethanol solution of petroleum ether and ether extractives of leaves of *Amianthemum muscaetoxicum*: 22 percent wormy, no stings.

(2) Ethanol solution of crude alkaloid of *Haplophyton cimicidum*: 28 percent wormy, 10 percent stung.

(3) Ethanol solution of petroleum ether and ether extractives of stems and bark of *Willardia mexicana*: 43 percent wormy, no stings.

Tests with extractives of the following plants resulted in 50 percent or more wormy apple plugs:

- Barbasco shrub
- *Piscidia carthagenensis* bark
- *Amanita muscaria*
- *Asclepias labriformis* stems
- Barbasco roots
- Ococate (*Eugenia* sp?) leaves and stems
- Barbasco leaves
- *Echinocystis fabacea* roots
- Barbasco seed (Jacquinia sp?)
- Barbasco stems
- *Chlorogalum pomeridianum* roots
- *Eupatorium compositifolium*
- *Humulus lupulus*
- *Garcia nutans* Rohr.
- *Circuta maculata*
- *Derris scandens* roots
- *Piscidia carthagenensis*
- *Eupatorium capellifolium*

Inorganic Compounds

Tests of synthetic cryolite and of 2 natural cryolites indicated that at dosages giving approximately equal percentages of sodium fluoaluminate, 20-23 percent wormy and 20-30 percent stung plugs resulted, there being practically no difference in effectiveness of the 3 materials.

Results of tests with a commercial run-of-the-mill sample of scorodite (micronized) containing 27 percent arsenic calculated as As_2O_5 showed this material to be ineffective against newly-hatched larvae.

POUGHKEEPSIE, NEW YORK

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These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the New York Agricultural Experiment Station at the Hudson Valley Fruit Investigations Laboratory, Poughkeepsie, N. Y.

Seasonal Developments

Extreme minimum temperatures during the winter of 1942-43 caused severe mortality of overwintering codling moth larvae. Of 3,371 larvae overwintering under paper-burlap bands in orchards scattered throughout the Hudson River Valley 82.5 percent were dead as compared to average mortality of less than 20 percent in similar examinations made in preceding years. In general, weather conditions during the growing season were extremely favorable for codling moth development, since temperatures were slightly higher than average and rainfall below normal, and 1943 was the worst codling moth year experienced since 1939.

Codling moth development started later in the season than usual due to low spring temperatures. Pupation began May 7, and the first moth was captured in bait traps May 24. Larvae began entering the fruit at Poughkeepsie June 8 and at Kinderhook June 12. The peak of spring brood moth captures occurred in bait traps June 2 to 3, and peaks of first brood captures occurred July 22-August 2 and August 14-15. Peak larval entrances, as determined by the removal of injured apples from unsprayed trees at 7 day intervals, occurred for the first brood from June 26 to July 2, and for the second brood from July 30 to August 13. Pupation ceased August 19 and the last moth was captured in bait traps September 29. Activity of moths and larvae during late August and September was greater than usual so that late injury was severe. Observations indicate that a few second-brood moths may have emerged in this locality and produced third-brood larvae.

Tests With Insecticides

(a) Spray Experiments

Randomized Plots: Eighteen spray schedules were compared on randomized single tree plots, replicated 4 times, in the Kinderhook area. The trees used consisted of medium-sized McIntosh, well

pruned, located on a level piece of ground. At least 80 percent of the crop had been injured by codling moth in 1942, so the infestation in the orchard was known to be one of the heaviest present in the Hudson River Valley area. Each plot received early season sprays consisting of a calyx and a curculio application, each containing 3 pounds of lead arsenate and 1 pound of lime per 100 gallons, and a special scab application using 2 gallons liquid lime-sulfur per 100 gallons. Micronized sulfur was included in the calyx, curculio, and first cover applications at the rate of 6 pounds per 100 gallons, on all plots.

Generally 6 cover sprays were applied for codling moth protection. The first 4 were timed against first-brood worm activity and the last 2 against second-brood worm attack. The dates on which applications were made and the amount of rainfall occurring between applications is shown below.

Dates of Application			Rainfall (inches)
Calyx	-	May 25	-
Curculio	-	June 8	2.27
Special scab	-	June 12	0.00
1st cover	-	June 16	0.16
2nd cover	-	June 25	0.44
3rd cover	-	July 6	1.94
4th cover	-	July 17	0.12
5th cover	-	August 5	3.34
6th cover	-	August 17	1.64
Harvest date	-	September 11	0.86
		Total	10.77

The treatments tested and the results obtained are shown in table 1, grouped so that schedules using similar materials may be readily compared.

Table 1.- Codling Moth Spray Experiments - N.Y.S. Orchard, Kinderhook, N.Y.-1943
Variety - McIntosh

Plot	Covers	Materials[1/] (Amounts per 100 gal.)	Apples per tree	Apples clean percent	Number per 100 apples: Worms[4/]	Stings	Harvest residues[2/] Gr. per lb. fruit[3/]
1	0	No insecticides	1928	20.5	81.8	27.3	
		Lead Arsenate					
2	1-2	LA 3 lb., L 1 lb.	2349	44.2	95.5	37.4	
3	1-2	LA 3 lb., L 1 lb.	1678	49.2	52.6	60.3	.025 AS
	3-4	LA 3 lb., L 3 lb., PSM 1/4 lb.					.062 Pb
4	1-2	LA 3 lb., L 1 lb.	2802	73.4	13.3	28.1	.051 AS.
	3-6	LA 3 lb., L 3 lb., PSM 1/4 lb.					.123 Pb.
		Cryolite					
5	1-2	S.cry. 3 lb.	2988	59.4	38.5	31.2	.066 F.
	3-6	S.cry. 3 lb., PSM 1/4 lb.					
6	1-2	N.cry. 3 lb.	2141	54.0	44.3	39.3	.074 F.
	3-6	N.cry. 3 lb., PSM 1/4 lb.					
7	1-2	LA 3 lb., L 1 lb.	2226	65.9	26.1	29.8	.084 F.
	3-6	S.cry. 3 lb., PSM 1/4 lb.					
8	1-2	LA 3 lb., L 1 lb.	2342	64.9	28.3	29.0	.058 F.
	3-6	72% N.cry. 3 lb., PSM 1/4 lb.					
9	1-2	LA 3 lb., L 1 lb.	2202	77.2	15.9	15.3	.119 F.
	3-6	S.cry. 3 lb., 875 oil 1 qt.					
		Spr. 19 cc.					
		Phenothiazine					
10	1-2	LA 3 lb., L 1 lb.	2228	95.1	2.6	3.2	.067 P.
	3-6	Pheno. 2 lb.					
11	1-2	LA 3 lb., L 1 lb.	2350	87.5	8.0	8.0	.053 P.
	3	Pheno. 2 lb., Spr. 8 oz.					
	4-6	Pheno. 2 lb., bl.alb. 2 oz.					
12	1-2	LA 3 lb., L 1 lb.	2962	89.1	6.8	6.7	.039 P.
	3-6	Pheno. 2 lb., Kero. 2 qt., bl.alb. 2 oz.					

Table 1 - continued

Plot	Covers	Materials[1/] (Amounts per 100 gal.)	Apples per tree	Apples clean percent	Number per 100 apples: Worms[4/]	Stings	Harvest residues[2/] Gr. per lb. fruit[3/]
		Nicotine					
13	1-2	LA 3 lb., L 1 lb., Spr. 4 oz.	1872	71.6	19.3	25.2	.019 AS.
	3,5-6	NB 1.5 lb., 875 oil 2 qt., Spr. 38 cc.					.044 Pb.
	4	LA 3 lb., L 3 lb., Spr. 6 oz.					
14	1-2	LA 3 lb., NTC 1.5 pt.	2206	78.2	10.3	21.5	.022 AS.
	3,5-6	NTC 1.5 pt., 875 oil 2 qt.					.051 Pb.
	4	LA 3 lb., L 3 lb., Spr. 6 oz.					
15	1-2	LA 3 lb., L 1 lb., NS 1 pt., Spr. 4 oz.	2953	83.5	6.0	15.7	.019 AS.
	3,5-6	NS 1 pt., 875 oil 2 qt., Spr. 38 cc.					.045 Pb.
	4	LA 3 lb., Spr. 6 oz.					
16	1-2	LA 3 lb., L 1 lb.	2292	68.0	25.8	24.3	
	3-6	NS 1/2 pt., 875 oil 2 qt., Spr. 38 cc.					
17	1-2	LA 3 lb., L 1 lb.	2490	83.2	9.0	13.2	
	3-6	NS 3/4 pt., Miss.Bent.5 lb., Soy oil 1 qt.					
		Thiocyanate					
18	1-2	LA 3 lb., L 1 lb., TC 1 pt., Spr. 49 cc.	2235	77.1	17.8	22.1	.016 AS.
	3,5-6	TC 1 pt., 875 oil 2 qt., Spr. 49 cc.					.038 Pb.
	4	LA 3 lb., L 3 lb., Spr. 6 oz.					

1/ LA=lead arsenate, L=lime, PSM=Powdered skim milk, S.cry.=synthetic cryolite, N.cry.=natural cryolite, Spr.=Proprietary oil soluble spreader principally pthalic glyceryl alkyd resin, 875 oil=summer mineral oil, Bl.Alb.=blood albumin Pheno.=micronized phenothiazine, Kero=kerosene, NB.=proprietary nicotine bentonite containing 14 percent nicotine, NTC=proprietary nicotine thiocyanate containing 12 percent nicotine, NS=nicotine sulfate, Miss.Bent.=Mississippi bentonite, TC=Proprietary thiocyanate containing 50 percent beta thiocyano ethyl esters of aliphatic fatty acids averaging 10 to 18 carbon atoms in a petroleum distillate.

2/ Lead and arsenic analyses by Chemistry Division, New York State Agricultural Experiment Station. Fluorine and phenothiazine analyses by Insecticide Division, U. S. Bureau of Entomology and Plant Quarantine.

3/ AS=arsenic, Pb=lead, F=fluorine, P=phenothiazine.

4/ Differences required for significance at 19:1 odds - 10.8.

Plot 1 received only sulfur applications for scab control and no insecticides. Eighty percent of the fruit was injured by codling moth. The low number of worms and stings, as compared to Plot 2, is accounted for by the fact that all injured fruits from Plot 1 were removed at 7 day intervals so that multiple injuries could not accumulate as in Plot 2.

Lead arsenate Plots 2 to 4, inclusive, were used as a standard of comparison for the control obtained with other insecticides and combinations. Plot 2 was included so that the control obtained with 2 covers of lead arsenate could be compared with that obtained with split schedules using lead arsenate in the first 2 covers. Six cover sprays of lead arsenate had 73 percent clean fruit at harvest and residues that exceeded the tolerance for arsenic and lead.

Six cover sprays of either synthetic or natural cryolite, Plots 5 and 6, failed to adequately control codling moth and fluorine residues at harvest greatly exceeded the tolerance. Mineral oil used as a sticker with synthetic cryolite in 4 cover sprays, Plot 9, increased control by building up heavier deposits of cryolite than in Plot 7, but did not result in outstanding control. The results obtained with natural cryolite containing 72 percent NA_3AlF_6, compared favorably with the control obtained with synthetic cryolite approximating 87 percent Na_3AlF_6. Differences between the control obtained with synthetic and natural cryolite were not significant. All the cryolite materials tested caused severe cracking of the apples and a roughening of the fruit which felt somewhat like russet. The results of these tests indicate that cryolite is unsatisfactory for use in codling moth control in this locality.

The codling moth control from micronized phenothiazine used alone (Plot 10) was outstandingly better than that obtained on any other plot or with other materials or combinations. Heavy splotches of visible residue were present on the harvested fruit which left an undesirable finish to the apples. The addition of 2 quarts of kerosene combined with 2 ounces of blood albumin smoothed out the cover and left less visible residue, although there was still a small amount of splotching, especially on the under side of the apples. Use of the wetters and spreaders reduced the initial deposit of phenothiazine which resulted in poorer codling moth control. However, the control obtained on Plots 11 and 12, where wetters and spreaders were used with phenothiazine, was greater than that obtained with lead arsenate in Plot 4 and compared favorably with the best nicotine schedules, Plots 15 and 17, although the differences were not significant. Phenothiazine deposits on the fruit and the rate of weathering following the last cover spray are shown in table 2. The figures given are the means of 4 samples of 15 apples for each analysis.

Table 2.- Effects of wetters and spreaders on phenothiazine deposits 1/

Plot	Materials per 100 gallons	Phenothiazine in mg. per apple			
		Aug. 16 (before spraying)	Aug. 17 (after spraying)	Aug. 27	Sept. 11 (harvest)
10	Pheno. 2 lb.	0.69	1.37	1.31	0.96
11	Pheno. 2 lb., Blood albumin 2 oz.	0.38	0.95	1.08	0.72
12	Pheno. 2 lb., Kerosene 2 qt., Blood albumin 2 oz.	0.35	1.07	0.80	0.57

1/ Analyses by Division of Insecticide Investigations, U. S. Bureau of Entomology and Plant Quarantine.

Nicotine sulfate in combination with lead arsenate as used in Plot 15 gave the best control of any nicotine schedules tested. This schedule is similar to that recommended for commercial control of codling moth in this area, although the amount of nicotine sulfate included in the lead arsenate applications is generally reduced to 1/2 pint per 100 gallons and cover sprays number 5 and 6 are omitted in lighter infestations or where the population of first-brood codling moth worms was very substantially reduced. Light to moderate burning of the leaves due to the application of oil following sulfur occurred where this schedule was applied. Plot 17, using the standard tank-mix nicotine bentonite formula, developed by L. F. Steiner and co-workers, in the last 4 cover sprays was the second most efficient nicotine schedule tested, but visible residues of bentonite left on the fruit at harvest were heavy and objectionable. A slight amount of sulfur-oil injury was also present on the leaves. Plot 14, treated with a commercial nicotine thiocyanate and lead arsenate, gave moderate control of codling moth, but foliage was severely injured by the sulfur-oil complex. This material is unsafe for use in combination with sulfur. The base of this material is also a heavy sticker as deposits of lead arsenate on the fruit at harvest were comparatively heavier than those on other plots receiving the same dosages of lead arsenate. Plot 16, using 1/2 pint of nicotine sulfate with 0.5 percent oil in 100 gallons produced only 68 percent clean fruit, although in former years this schedule has adequately protected the fruit from codling moth injury. Sulfur-oil injury was present on the leaves in light to moderate amounts.

Thiocyanate, used on Plot 18 in combination with lead arsenate in the first and second covers, and with summer oil at ovicidal strength in the third, fifth, and sixth covers, produced about the same amount of clean fruit as 6 covers of lead arsenate alone, although a very smooth film type of deposit was laid down. Since this material was used in combination with lead arsenate and oil the amount of control resulting from the thiocyanate could not be determined, but it seemed to be small. Sulfur-oil injury on the leaves was present in moderate amounts.

Foliage injury, beginning in the form of long brown areas adjacent to the mid-rib of the leaves, was noticed on Plot 14 as early as June 25. At this time the amount present was not important. By July 6 the injury had increased on Plot 14 and was noticeable on Plot 18. By July 16 this injury could be noticed on about two-thirds of the trees in the entire spray block. Careful investigation on that date showed light injury in Plots 9, 16, and 17, light to moderate injury in Plots 13 and 15, moderate injury in Plot 18, and severe injury in Plot 14. This injury showed up wherever oil or oil base materials had been used in the spray schedule and was the most serious in instances where oil base materials were applied in combination with sulfur, although some injury occurred even though a period of 20 days elapsed between the last sulfur application and the first oil application. Heretofore such injury has not occurred in schedules where oil followed sulfur after a period of 20 days.

First-Brood "Annihilation" Sprays: First-brood "annihilation" or "double action" schedules, which had been used successfully during the past three seasons for codling moth control in small isolated orchards, were applied along side the replicated plot experiments on blocks 4-tree-rows wide and 11-tree-rows long. These blocks were practically surrounded by trees in which the codling moth was not being effectively controlled. Migration of moths from these trees was so great that the annihilation programs were ineffective. While infestation records were not taken at the end of first-brood attack observations indicated that most of the injury occurred during second-brood activity. The annihilation schedule reported last season as producing 97.9 percent clean fruit in a heavily infested isolated orchard gave only 74.5 percent clean fruit in this test. The other schedule used had thiocyanate substituted in place of nicotine sulfate and nicotine bentonite resulted in only 55.1 percent clean fruit.

In insectary tests set up to determine the effect of nicotine sulfate on adult moths, all caged moths contacted by the spray at concentrations as low as 1 to 3200 were killed. Similar results were secured in cages placed in the trees in the orchard prior to spraying with the concentration of 1 to 1600 used in the annihilation schedule. However, where tests were arranged either in the insectary or field so that the caged moths were not directly contacted but were held in the proximity of the sprays and its fumes for several minutes comparatively small numbers were killed. Apparently the nicotine released in the annihilation sprays acts as a contact insecticide and has little fumigating value against the adult moths.

Tests with thiocyanate indicated that this material at dosages of 1 to 800 had little effect upon caged moths contacted by the spray.

Apples having entries less than 24 hours old were dipped in solutions of thiocyanate 1-800 and nicotine sulfate 1-1600 in order to determine the effect of the annihilation sprays on young larvae that had already entered the apples at the time of spraying. All

of the larvae in apples dipped in thiocyanate survived, while only 47 percent of those in apples dipped in nicotine sulfate survived, and 93 percent of the larvae in apples dipped in water survived.

(b) Dust Experiments

Each of five different dust schedules was applied to a row of 15 trees across a McIntosh orchard, the treatments being separated from each other by 3 or 4 rows of trees sprayed with the grower's schedule. The codling moth control obtained with each dust treatment was compared with that on paired trees in an adjacent sprayed row. Infestation records were also taken on a sprayed row separated from all dusted rows by 3 sprayed rows in order to be certain that the data obtained from the sprayed plots were unaffected by nearby dust treatments.

A Niagara cyclone orchard duster was used, the trees being dusted from both sides during each application. Eight applications of dust were made. Five of these were timed for control of first-brood codling moth worms and were applied at approximately 7-day intervals. The last 3 applications were timed against second-brood worm attack. The most satisfactory time of day for dusting was found to be just after daybreak. At this time of day the foliage was usually damp, which helped stick the dust to the trees, and wind velocities were at a minimum. The amount of material used for a medium sized tree at each application varied from an average of 2.2 pounds for schedule 1 to 3.5 pounds for schedule 4, although it was intended that dosages for all plots should average 2.5 pounds per tree. The dates on which dust applications were made and the amount of rainfall occurring between applications follow.

Dates of Dust Applications		Rainfall (inches)
1st cover	- June 11	-
2nd cover	- June 18	0.24
3rd cover	- June 24	0.59
4th cover	- July 2	1.17
5th cover	- July 9	1.12
6th cover	- August 3	3.58
7th cover	- August 11	0.45
8th cover	- August 19	0.82
Harvest date-	September 13	1.00
	Total	8.97

The spray treatments were applied by the grower using modern spray equipment with single nozzle guns at approximately 500 pounds pressure. Approximately 15 gallons of spray were used for each tree for each application. Four applications, 3 during the period of first-brood worm activity and the 4th during the period of second-brood attack, were made during the season. Sprays were applied June 12-13, 23, July 2, and August 10.

Detailed information on the spray and dust schedules tested and the results obtained are given in table 3.

Table 3.- Comparison of various dust schedules with grower's standard spray schedule for control of the codling moth. Poughkeepsie, N.Y. 1943.

Schedule Number	Covers Number	Schedules: Materials and proportions used
		DUSTS
1	1-8	Lead arsenate 20%, micronized sulfur 80%
2	1,3,6,7	Lead arsenate 20%, nicotine bentonite 20%, micronized sulfur 60%
	4,5,8	Same as schedule 1
3	1,3,6,7	Lead arsenate 20%, nicotine bentonite 10%, 100-viscosity oil 2%, micronized sulfur 68%
	4,5,8	Same as schedule 5
4	1,3,6,7	Lead arsenate 20%, nicotine bentonite 20%, 100-viscosity oil 2%, lime 20%, micronized sulfur 38%
	4,5,8	Same as schedule 5
5	1-8	Lead arsenate 20%, 100-viscosity oil 2%, micronized sulfur 78%
		SPRAYS
All schedules 1/	1,2	Lead arsenate 3 lb., nicotine sulfate 5/8 lb.(1/2 pt.), lime 3 lb., sulfur 8 lb.
	3,4	Nicotine bentonite 3 lb., sulfur 4 lb.

Row and Schedule Number	Treatment	Apples Per Tree	Clean Fruit	Injuries per 100 apples: Worms	Injuries per 100 apples: Stings	Residue at harvest Per pound of fruit 2/: Arsenic	Residue at harvest Per pound of fruit 2/: Lead	Cost Per Tree
		Number	Percent	Number	Number	Grain	Grain	
1	Dust	3100	82.4	15.3	9.5	0.012	0.027	$1.57
1-A	Spray	2741	86.2	12.1	8.0			1.50
2	Dust	3574	88.3	7.9	7.1	0.017	0.038	2.73
2-A	Spray	4187	89.8	7.4	6.2			1.50
3	Dust	3920	89.8	6.0	7.0	0.025	0.055	2.19
3-A	Spray	3459	88.4	7.9	7.0			1.50
4	Dust	4239	93.0	4.5	4.4	0.022	0.051	2.69
4-A	Spray	4146	90.8	6.8	5.3			1.50
5	Dust	4312	88.5	8.2	7.0	0.022	0.050	1.57
5-A	Spray	3870	91.4	5.6	5.2			1.50
6	Spray	2730	89.2	7.0	6.8	0.005	0.013	1.50

1/ Amounts per 100 gallons.

2/ Analyses by Division of Chemistry, New York State Agricultural Experiment Station.

The lead arsenate dust schedules appeared to be somewhat less effective than the spray schedules in codling moth control, in spite of the fact that twice as many dust applications were made. The addition of oil increased the adhesiveness of the lead arsenate dusts. This was true of both the initial deposits and of the deposits determined after periods of weathering. There was, however, little evidence of increased control, based on comparisons with that in adjacent sprayed rows. The best results were obtained with dusts to which nicotine bentonite had been added, especially that used in Plot 4, which included in five of the applications 20 percent of nicotine bentonite, 2 percent of oil, and 20 percent of lime, in addition to the lead arsenate and sulfur. The lime in this dust mixture caused a rapid release of part of the nicotine present, which may have killed a number of adult moths by contact. In tests conducted with caged moths large numbers of the moths were killed with this dust under laboratory conditions, but under field conditions smaller numbers were killed. Under field conditions caged moths placed near the center of the tree so that they were protected from the direct blast of the duster had a much higher percent of survival than those placed where they were unprotected from the dust stream. The lime also changed the texture of the dust so that it flowed from the duster more readily and deposited a smoother cover.

Residue analyses at harvest time showed that apples dusted with schedules 3 and 4 carried slightly more lead than the present tolerance of 0.050 grain per pound of fruit. Arsenic deposits were within tolerance. It is believed that residues left on the apples by this schedule would generally be within tolerance after the fruit had been given the usual handling.

Micronized sulfur used as a carrier for the insecticides in the dusts tested and as a fungicide for scab control caused cheek scald on a small percentage of the fruit. Where oil was included in the schedule the percentage of cheek scald increased slightly. This injury could probably be avoided by using a carrier other than sulfur for July and August applications when scab has been controlled earlier in the season.

The cost of operating the duster was less than that for a sprayer but the cost of materials was greater, especially when nicotine bentonite was included in the formula. Since dusts weather more rapidly than sprays 8 dusts were applied during the period the grower applied 4 sprays. Comparative costs for the dust and spray schedules used appear in the table. The figures include the cost of maintenance and operation of the duster and spray rig and are based on the application of 3,000 gallons of spray in 9 hours for 3 men, and the dusting of 5 acres of orchard in 1 hour for 2 men. Labor was figured at 60 cents per man hour.

While the codling moth control obtained with the better dust schedules compared favorably with that obtained by the grower's spray schedule in a moderately infested codling moth orchard, the schedules used were entirely experimental and are not recommended for general use.

Bait Trap Experiments

Five series of bait traps were compared in single tree plots arranged in a Latin-square. Comparisons were made between sassafras-sugar baits, apple ester-sugar bait, both changed at 20-day intervals, and sassafras-sugar bait changed between broods only. Comparisons were also made between the standard double quart glass trap, the same type of trap with the upper third and the screen top painted with luminous violet N, and the same type of trap with the upper third and the screen top painted with luminous blue. Moth captures for the season are shown in table 4.

Table 4.-Codling Moth Captures in Bait Traps, 1943

Bait Number	Bait Solution (Materials and amounts per quart)	Trap	Number of Moths Captured: May	June	July	Aug.	Sept	Total
1	Oil sassafras 1/2 cc. No.13 brown sugar 1 lb. Changed at 20-day intervals	Glass, unpainted	97	672	302	441	50	1562
2	Same as 1 with 1/4 gr. sodium benzoate added 10 days after put out Changed July 10 only	Glass, unpainted	85	582	337	467	43	1514
3	Apple esters (1% sol.) 100 ml. No.13 brown sugar 1 lb. Changed at 20-day intervals	Glass, unpainted	29	251	5	Discontinued July 20		
4	Same as 1 Changed at 20-day intervals	Glass, top third painted with luminous Violet N.	82	797	301	375	29	1584
5	Same as 1 Changed at 20-day intervals	Glass, top third painted with luminous blue	116	721	340	380	31	1588

There was no difference between the effectiveness of the sassafras-sugar baits 1 and 2, changed at 20-day intervals or only between broods.

The apple esters used in bait 3 are a byproduct of the Bland apple syrup developed by the Bureau of Agricultural and Industrial Chemistry at the Eastern Regional Research Laboratory, and was supplied in a dilute 1 percent solution containing 0.1 percent sodium benzoate as a preservative. As used in this test, this material was much less attractive to codling moths than oil of sassafras. During warm weather

the apple ester baits soured within a few days after being placed in the orchard and the traps filled with blow flies. This bait fermented much more rapidly than the oil of sassafras bait and the fermentation ceased entirely within 10 days. The apple esters were further tested as attrahents for codling moths by suspending traps containing the 1 percent juice, and 1 percent juice with 12 percent brown sugar, in trees near bait 1 for a period of 20 days. These solutions captured only a few moths during the 20 days they were out.

The differences between captures in traps treated with luminous paints, baits 4 and 5, and captures in unpainted glass traps, bait 1, do not appear to be significant.

Apple Maggot Investigations, Poughkeepsie, N. Y. 1943

R. W. Dean, Division of Entomology, New York Agricultural Experiment Station, in cooperation with U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine, Division of Fruit Insect Investigations.

Injury from apple maggot was more severe in eastern New York in 1943 than during the past several years. The exact cause has not been determined but seems to be a combination of several factors. In some instances, spraying was stopped too early in the season. Emergence of flies was continued somewhat later than usual, with the result that wherever late applications were omitted control was poor. Field control tests showed that properly timed applications of effective materials gave adequate control.

Shortened, intensified schedules, as proposed by Garman in Connecticut, were tested in two blocks. The dates of application and spray materials used, expressed in amounts per 100 gallons, were as follows:

Application	Date	Orchard A	Orchard B	
Late Delayed Dormant	May 4	Liquid lime sulfur 2 gal. Lead arsenate 3 lb. Hydrated lime 3 lb.	Liquid lime sulfur 2 gal.	
Pink Spray	May 11-13	Fermate 1 1/2 lb. Hydrated lime 1 1/2 lb.	Fermate 1 1/2 lb. Hydrated lime 1 1/2 lb. Sticker Spreader 1/4 pt.	
Calyx Spray	May 24	Aluminum aceto-formate (24% sol.) 1 pt. Benzoic acid 1/4 lb. Manganese borate 1/4 lb. Summer oil 1/2 gal. Lead arsenate 6 lb. Fermate 1 1/2 lb.	Monoethanolamine 1 part) Water 12 parts) Kerosene 3 parts) 19 parts) Fish oil 1 part) Oleic acid 1 part) Lead arsenate Fermate	1/2 pt. 1/2 gal. 3 lb. 1 1/2 lb.
Curculio Spray	June 2	Same as Calyx Spray except Fermate 1 lb.	Same as Calyx spray except Fermate 1 lb.	
First Cover Spray	June 12-14	Same as Curculio spray except lead arsenate 3 lb.	Same as Curculio spray	

Control data were taken on apple maggot, plum curculio and apple scab by counting all the fruit from selected trees. The 1942 maggot infestation in Orchard A was 1,032 percent, but an unsprayed check tree showed 40.55 percent maggot injury in 1943. The estimated 1942 maggot infestation in Orchard B was 95-100 percent. An unsprayed check tree in an adjoining block which, in 1942, averaged 6.33 percent maggot injury, showed 50.34 percent injury in 1943. The initial infestations were, therefore, quite different in the two blocks, but conditions in both were favorable for heavy maggot infestation during the 1943 season. The control results are shown below.

Orchard	Apple Maggot % Control	Plum Curculio % Control	Apple Scab % Control	Clean %
A	74.6	63.2	92.0	63.6
B	0	66.8	59.5	30.7

Under conditions of light initial infestation, the schedule followed in Orchard A gave satisfactory maggot control, considering that an unsprayed tree was left in the middle of the planting. Scab control was good but curculio control was, at best, only fair. With a much higher initial infestation, the spray program used in Orchard B failed to control the apple maggot. Curculio control was not much better than in Orchard A, and scab infection was considerably greater.

Spray residues on fruit and foliage in the two orchards were as follows:

Date	Orchard A As_2O_3	Orchard A Pb	Orchard B As_2O_3	Orchard B Pb	
June 28	24.42	49.57	17.71	38.93	Foliage (mg./100 sq.in.)
July 20	20.00	41.42	16.55	32.82	Foliage (mg./100 sq.in.)
Sept. 8,14	0.011	0.026	0.018	0.044	Fruit (gr./lb.)

The heavier lead arsenate applications in Orchard A resulted in a greater deposit on the foliage than in Orchard B, but fruit residues were lighter, indicating a possible difference in adhesiveness to fruit and foliage surfaces.

A third planting was sprayed twice with synthetic cryolite, at the rate of 4 lb, per 100 gallons, plus micronized wettable sulfur at 6 lb. per 100 gallons. The applications were made at the usual times for apple maggot sprays, a few days after emergence started and at the peak of emergence. These dates were June 25 and July 19 in 1943. In 1942, the estimated maggot infestation was 75 percent. In 1943 the average degree of infestation in the sprayed trees was 96.7 percent. At harvest, the average fluorine residue was 0.016 grain per pound of fruit. No spray injury resulted.

An orchard of prune trees, which had been infested with apple maggot for several years, was sprayed twice with micronized phenothiazine at 2 lb. per 100 gallons, the applications being made on June 26 and July 20. An average of 0.0175 maggot per fruit was reared from the entire crops of six trees. Since the infestation during the previous season is not known, the degree of control obtained could not be determined.

YAKIMA, WASHINGTON

E. J. Newcomer, In Charge

Seasonal Conditions

The winter of 1942-43 was the coldest for some years, the average temperature being nearly 5 degrees below normal. Unseasonably warm weather April 11-15 brought fruit blossoms out rapidly, and apples were only a few days later in blooming than in 1942. May and June temperatures were 2 degrees below normal, with very little rainfall, and temperatures during the rest of the summer were above normal, the average for September being 7.5 degrees above normal. This resulted in a considerable amount of late infestation.

Bait records were made in the same orchards as in previous years, and were as follows:

	Rome Orchard			Winesap Orchard			Delicious Orchard		
Year	Spring brood	First brood	Total	Spring brood	First brood	Total	Spring brood	First brood	Total
1941	16949	11784	28733	6708	9432	16140	3152	3295	6447
1942	4914	15313	20227	2233	14969	17202	751	3441	4192
1943	11112	17897	29009	4008	19634	23642	2305	915	3220

The fall of 1941 was cool, and a light infestation occurred, resulting in a relatively light spring brood in 1942. The fall of 1942 was warm and the infestation heavier, and this is reflected in the spring-brood moth catch for 1943. In spite of the large number of moths caught in the Rome orchard throughout 1943 the fruit as a whole was less wormy than in 1942, although the reverse was true in the Winesap orchard. Frost in April 1943 wiped out the apple crop in the Delicious orchard and there was only a little fruit on the interplanted pear trees, which accounts for the small number of first-brood moths caught in that orchard this year.

Biological Studies

Moth emergence and egg deposition.

Moths that developed from overwintering larvae began to emerge about the first of May, the peak occurred during the week

ending May 28, and emergence continued into the fore part of July. The emergence of first-brood moths reached a peak about August 15-25, and considerable numbers were caught in baits until the middle of September.

Egg deposition started about May 18, or about the same time as in 1942, and a considerable number of eggs were deposited from May 23 to 28. Freshly deposited eggs were found on apples throughout June. The greatest numbers of second-brood eggs occurred August 17-31.

Larval development.

Larval entrances were first found June 1 and many entries were made during the first 10 days of June. Entries then slackened off somewhat but increased again during the last week of June and continued to increase slowly until the first of September, after which there was a more rapid increase for several weeks. Mature larvae of the first brood began to leave the fruit about July 1 and a peak was reached during the week ending July 28. During August there was a decrease, and the second-brood larvae left the fruit in maximum numbers during the week ending September 22.

Orchard Spraying Experiments

It was planned to use the same three orchards for spraying experiments as in previous years, but frost late in April completely destroyed the crop in the Delicious orchard. The tests intended for that orchard were therefore carried out in the Rome orchard adjacent to the experimental plat already laid out there. These were designated as series B and the other tests in the same orchard series A. The Rome orchard is about 20 years old, and had a rather heavy and uniform crop in 1943, averaging about 17 boxes to the tree. The infestation was somewhat lighter than in 1942. The other tests were conducted in an orchard consisting of Winesaps and Jonathans, about 30 years old, with a light and irregular crop, averaging only 7 boxes to the tree, and a much heavier infestation than in 1942. Single-tree plats were used, replicated 8 times in each orchard. From each tree random samples of 250 apples were taken at harvest, including both picked and dropped fruit.

A calyx and six cover sprays were applied in the Rome orchard as follows: Calyx, May 10-12; First Brood, 1st cover, May 28-29; 2nd cover, June 8-11; 3rd cover, June 19-23; 4th cover, July 1-3;

Second Brood, 5th cover, July 26-28; 6th cover, August 12-14. On account of the heavier infestation, a calyx and seven cover sprays were applied in the Winesap and Jonathan orchard on the following dates: May 3, May 24-25, June 5-7, June 15-17, June 28-29, July 19-20, August 3-4, August 17-18.

Deposit analyses for each treatment were made on Romes and Winesaps before and after each cover spray and the average of these are shown in table 1. The analyses were made by C. C. Cassil, formerly of the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine. Residues of arsenic, nicotine, phenothiazine, and xanthone were determined by the respective methods mentioned in last year's report (see Results of Codling Moth Investigations, 1942, Part II, page 60). One-ten hydrochloric acid plus chloroform was used as the solvent for fluorine residues which were determined by a zirconium-purpurin titration procedure developed by the Food and Drug Administration. Some deposit analyses were made on Jonathans to determine how lead arsenate and cryolite were adhering to that variety, but not enough analyses were made to show a seasonal average. Analyses of arsenic, nicotine and fluorine deposits were made on September 29, and these are shown as "harvest" residues in the table. All results were calculated as micrograms per square centimeter of apple surface.

Table 1. Average spray residues expressed in micrograms per square centimeter. Yakima, Washington, 1943.

Treatment 1/	Residue	ROME Before Spray	ROME After Spray	ROME Harvest	WINESAP Before Spray	WINESAP After Spray	WINESAP Harvest	JONATHAN Harvest
1	As_2O_3	20.1	40.2	22.9	21.8	41.7	34.9	31.0
1a	As_2O_3	15.9	34.1	23.2				
3	Phenothiazine	8.0	19.4					
4	Phenothiazine	8.4	22.0		8.8	22.0		
5	Phenothiazine	8.3	21.5		8.4	20.6		
6	Phenothiazine	4.4	12.1					
7	Xanthone 2/	15.7	36.4		7.8	24.9		
8	Nicotine	5.5	10.4	7.1	5.3	9.9	5.8	
9	Nicotine	4.1	7.4	1.5	4.2	7.0	5.5	
10	Fluorine	28.7	50.0	42.1				63.6
11	Fluorine	27.6	54.8	53.2				
12	Fluorine	12.1	26.1	11.0				

1/ See table 2 for details of treatments.
2/ Nicotine used in first two cover sprays.

The average deposit of As_2O_3 in 1943 was about 25% higher than in 1942, and since this is used as the standard, the other materials were tested under more exacting conditions than in 1942. The average deposit from 1 pound of phenothiazine was slightly higher in 1943 than in 1942, the xanthone deposit was about the same on Winesaps but higher on Romes, but the nicotine deposit was 50 to 60% higher in 1943 although the same quantity of nicotine was used per 100 gallons both years. It was as high as had been obtained in the other seasons from twice the quantity of nicotine. Since cryolite has not been used in recent years, no comparisons of deposit are possible.

The results of the field spraying experiments are given in table 2. The lead arsenate treatment (1) was an improvement over the one used in 1942 and put on a somewhat heavier deposit. The same formula was tried in treatment 1a, except that only three cover sprays, somewhat farther apart, instead of four, were applied against the first brood. While this did not result in significantly more wormy fruit, the percentage of fruit injured was significantly greater.

Table 2: Comparative efficiency of insecticides used in field spraying experiment. Yakima, Washington, 1943

No.	Treatment (Quantities per 100 gallons) [1]	Rome Orchard Series A % wormy	Rome Orchard Series A % injured	Rome Orchard Series B % wormy	Rome Orchard Series B % injured	Winesap Orchard % wormy	Winesap Orchard % injured
1	Lead ars. 3 lb.; mineral oil (emulsible) 1 qt.; spreader 1/4 lb.[2]; alum. sulf. 1/3 oz.	4.9	8.8	7.5	19.4	37.2	71.2
1a	Same as 1, one less first brood spray	8.0	15.2				
3	Phenothiazine 1 lb.; stove oil or kerosene-casein emulsion 1 qt.[3]	.6	.8				
4	Phenothiazine 1 lb.; stove oil or kerosene-casein emulsion 1 or 2 qt.[3]; oleic acid 1/6 pt.[4]; alum. sulf. 2 oz.	1.6	1.8	7.1	8.8	23.0	30.4
5	Phenothiazine (sublimed) 1 lb.; as in 4.	2.8	3.2	9.2	11.4	44.3	50.2
6	Phenothiazine (sublimed) 1/2 lb.; as in 4.	7.6	8.7				
7	Nicotine-bentonite as in 8, first 2 sprays; then xanthone 2 lb.; kerosene 1 qt.; spreader, 1 1/3 oz.; oleic acid 50 cc.; alum. sulf. 2 oz.	2.0	2.8	5.2	8.1	23.3	31.8
8	Nicotine bentonite, dry-mix, 1-5, micronized 3 lb.; mineral oil 1 or 2 qt.[5]; oleic acid 4 oz.; alum. sulf. 2 oz.	5.5	7.8	21.6	27.2	32.4	45.2
9	Nicotine-bentonite, dry-mix, 1-10, micronized 4 lb.; mineral oil 1 or 2 qt.[5]; oleic acid 1/2 pt.; alum. sulf. 2 oz.	19.0	22.6	35.4	41.2	40.7	53.8
10	Natural cryolite (90%) 3 lb.; mineral oil (emulsible) 1 qt.; spreader 1/6 lb.	6.7	19.0				
11	Natural cryolite (70%) 3 lb.; as in 10.	6.8	17.2				
	Differences required for significance (19 to 1)	4.7	5.9	10.4	11.2	14.9	17.7

1/ Calyx spray lead arsenate 2 lb. to 100 gal. in all tests.

2/ 2/3 pint of a different spreader used in 1st and 2nd cover sprays.

3/ Stove oil or kerosene 3 gal., water 1 gal., casein 6 oz., ammonium hydroxide 56 cc., cresol (preservative) 10cc.

4/ Emulsion reduced to 1 qt. and oleic acid added separately instead of being first added to the emulsion in 4th to 6th cover sprays.

5/ Two qt. in 1st three cover sprays.

There was no significant difference in results between micronized phenothiazine at 1 pound with the old stove oil-casein emulsion (3) or with the newer mixture (4), or the sublimed material used in the same manner (5). This latter material was tried because it contained an anti-oxidant which should prevent it from turning dark. It did turn dark, however, and it was found that the effect of the anti-oxidant had evidently been destroyed in the micronizing process. This material used at 1/2 lb. (6) resulted in significantly more wormy fruit than at 1 lb. There was, however, no significant difference between any of the phenothiazine treatments and the lead arsenate treatment (1) as regards wormy fruit, although treatment 3 on the Romes and treatment 4 in the case of both varieties were significantly cleaner than 1 as regards total injuries while treatment 5 had significantly fewer injuries in the Winesaps.

Xanthone used at 2 lb. in an improved formula (7), which put on a somewhat heavier and more uniform deposit, had significantly fewer total injuries than the lead arsenate, but the wormy fruit, although less, did not differ significantly.

Nicotine bentonite, also used in an improved formula (8), and putting on a much higher deposit than previously, gave results at least equal to those from lead arsenate in all but series B in the Rome orchard, and even here despite a lighter crop and larger fruit the total injuries were not significantly greater than from lead arsenate. Nicotine bentonite at 1-10, as used in treatment 9, was unsatisfactory. The deposit was too light and too spotted.

Cryolite, which has not been tested for some years, was again tried in 1943. Both the usual material containing about 90% cryolite and a 70% cryolite were used (in treatments 10,11) on Romes and there was no difference between them in the control effected. They were not significantly different from lead arsenate in terms of wormy apples but were significantly poorer in terms of total injuries. This result is contrary to the opinion of many growers, who believe they get fewer stings from cryolite.

Owing to a shortage of labor, no records were taken on the color of the fruit in 1943. However, the fruit sprayed with phenothiazine appeared to have less color than the other fruit, as in previous seasons. The average number of apples per box resulting from the various treatments is given in table 3.

Table 3. Size of apples resulting from different spray treatments. Yakima, Washington, 1943.

Plat	Treatment 1/	Size (Av. No. apples per box) Rome A	Rome B	Winesap
1	Lead arsenate 3 lb.	93	98	149
1a	Do., 5 covers	93	--	---
3	Phenothiazine 1 lb., stove oil-casein emulsion.	110	--	---
4	Phenothiazine 1 lb., stove oil-casein emulsion, oleic acid.	105	103	179
5	Phenothiazine (sublimed) 1 lb. as in 4.	98	102	173
6	Phenothiazine (sublimed) 1/2 lb. as in 4.	96	--	---
7	Xanthone 2 lb., kerosene, spreader, oleic acid.	94	91	160
8	Nicotine bentonite, dry mix, 1-5, 3 lb., mineral oil, oleic acid.	89	83	140
9	Nicotine bentonite, dry mix, 1-10, 4 lb., mineral oil, oleic acid.	81	89	147
10	Cryolite (90%) 3 lb., mineral oil, spreader.	90	--	---
11.	Cryolite (70%) 3 lb., as in 10.	92	--	---

1/ For details of treatment, see table 2.

Use of Sprays to Kill Hibernating Codling Moth Larvae on Trunks

Large scale orchard tests were made in 3 orchards in 1943. Sprays were applied in late March and early April on blocks of 120-140 trees, using a regular portable gasoline-power sprayer with the pressure reduced to 150 pounds. From 3 to 5 gallons of spray were applied per tree, using bordeaux nozzles attached to spray rods. An attempt was made to cover the trunks and most of the rough bark part of the scaffold limbs.

The two spray mixtures tested contained the following materials:

Quantities per 100 gallons	Mixture A	Mixture B
4,6 dinitro-o-cresol	4 lb.	3 lb.
Stove oil	10 gal.	15 gal.
Sodium lauryl sulfate	4 lb.	3/8 lb.
Ethylene glycol monobutyl ether	1.5 gal.	
Trichloroethylene	1.5 gal.	
Ferric chloride		3.78 grams

The sprays were prepared in the orchard by dissolving the dinitro compound in the oil by heating. While this was being done, the required quantities of water and emulsifier were placed in the spray tank with the machine running. The solution of dinitro-o-cresol in oil was then added through the spray pump injector, followed by the penetrant or the ferric chloride.

The sprays were applied during the period March 25 to April 6, mixture A being used in all 3 orchards and mixture B in only one. The trees in the latter orchard were very large and old with much rough bark higher up than could be reached with the 5 to 7-foot spray rods. In addition, it was windy while most of the spraying was done in this orchard, which made it difficult to drench the upper scaffold limbs thoroughly and an application of dormant lime sulfur by the grower shortly after the DN sprays were applied tended to interfere with the proper functioning of the latter.

Mixture A resulted in a 94 percent kill of overwintering larvae in the first two orchards, which was in excellent agreement with the mortality caused by that mixture in tests conducted in 1941. Only 86 percent mortality resulted in the third orchard where conditions were less favorable. The kill from mixture B, tested in the third orchard only, was only 80 percent. Apparently because of moth migration, no significant reduction of moth population as shown by moth captures in two bait pots per plat maintained in 2 of the orchards was shown either for the spring brood or the whole season.

Harvest counts were made in only one orchard; loss of crop or inadequate and irregular spraying made counts in the other two orchards impractical. The results from counts on 20 trees in each block in the one orchard were as follows:

Treatment	Percent wormy at harvest	
	Jonathan	Winesap
Check	40	33
A	30	19
B	25	19

KEARNEYSVILLE, WEST VIRGINIA

Edwin Gould, West Virginia Agricultural Experiment Station and G. H. Geissler, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the West Virginia Agricultural Experiment Station.

Seasonal Conditions and Codling Moth Abundance During the 1943 Season

The 1943 season in the Shenandoah-Cumberland fruit belt was one of extreme drought. Temperatures were uniformly high, thus accelerating codling moth injury. Severe frosts early in the season caused further reductions of an already light apple bud set.

The first moth appeared in bait pails on May 7. Peaks of activity occurred on May 19 and May 24. During the early part of May cool weather delayed hatching. Once hatching began, however, entries maintained a rather high level throughout the season. Harvest operations were begun earlier than normal due to high prices and dry weather. Despite the fairly light crop there will be an unusually heavy carryover of hibernating larvae during the winter.

Field Testing of Insecticides

Gatrell and Border Orchard Tests

Phenothiazine was again thoroughly tested in duplicate orchards. These orchards were the Gatrell and Border, on the York Imperial and Stayman Winesap varieties. The schedules used and the results are summarized in table 1.

Table 1. Results of field experiments with insecticides for codling moth control--Gatrell and Border Orchards, Kearneysville, West Virginia, 1943.

Treat-ment No.	Cov-ers	Materials 1/ (Amounts per 100 gal.)	Gatrell Orchard Total fruits	Gatrell Orchard Injuries per 100 fruits Worms	Gatrell Orchard Injuries per 100 fruits Stings	Border Orchard Total fruits	Border Orchard Injuries per 100 fruits Worms	Border Orchard Injuries per 100 fruits Stings
1	1	LA 3#, L 6#, FS 6#						
	2-5	LA 3#, Bord. 2-4-100	18,086	5	49	11,354	104	409
2	1-4	LA 3#, ZS 1/2#, L 2#						
	5	LA 3#, Bord. 2-4-100	18,742	7	43	12,974	90	388
3	1	LA 3#, FS 6#, L 3#						
	2-4	LA 3#, ZL 1/2-2-100, L 2#, As 3 gal.	24,842	4	31	15,646	97	322
	5	LA 3#, Bord. 2-4-100						
4	1,4,5	MP 3#						
	2,3	MP 3#, SO 3 qt.	20,827	19	5	12,901	54	10
5	1-5	MP 3#	20,340	9	2	14,741	44	5
6	1-5	OMP 3#	20,699	8	2	12,433	40	7
7	1-5	OMP 3#	24,085	6	2	13,135	40	6
8	1-4	MP 1#, KO 2 qt.	27,894	28	6	13,050	95	15
	5	MP 3#						
9	1-4	MP 1#, KOOA 2 qt.	18,492	28	5	13,676	84	11
	5	MP 3#						
10	1	LA 3#, N 1 pt. ZL 1/2-2-100						
	2,3	LA 3#, N 1 pt., SO 4 qt., ZL 1/2-2-100	23,117	1	25	17,245	31	181
	4	LA 3#, ZL 1/2-2-100						
	5	LA 3#, Bord. 2-4-100						
11	1	LA 3#, ZL 1/2-2-100						
	2,3	LA 3#, N 1 pt., SO 4 qt., Bord. 2-4-100	28,480	3	23	12,444	82	348
	4,5	LA 3#, Bord. 2-4-100						
12	1	LA 3#, ZL 1/2-2-100						
	2,3	LA 3#, KOOA 2 qt., Bord. 2-4-100	19,166	7	50	16,244	106	401
	4	LA 3#, Bord. 2-4-100						

1/ LA - lead arsenate

FS - flotation sulfur

ZS - zinc sulfate

As - apple sauce

MP - micronized phenothiazine (plain)

OMP - "old" (1942) micronized phenothiazine (plain)

N - nicotine sulfate (40% nicotine)

1/ (Continued)

L - hydrated lime	CMP - micronized phenothiazine (conditioned)
Bord. - bordeaux	KO - kerosene oil emulsion (Yakima formula)
ZL - zinc lime	KOOA - kerosene oil oleic acid emulsion (Yakima formula)
SO - summer oil emulsion	

Phenothiazine

This material when used at the rate of 3 pounds per 100 gallons gave better control of codling moth than any of the lead arsenate combinations. There was little difference between the "plain" and "conditioned" forms in either orchard. The phenothiazine plots, while showing substantially greater numbers of fruits in the "wormy" class, nevertheless packed out far better than any of the lead arsenate treatments.

Treatments 5 and 7 were identical except that No. 7 was micronized phenothiazine that had been held for one year. Number 7 appeared slightly more effective in both orchards but whether or not this is due to "aging" of the material is open to question.

No fruit or foliage injury was apparent on any of the phenothiazine plots except No. 4 to which summer oil emulsion was added. Here fruit and foliage showed a very serious burning.

Lead Arsenate

In the heavily infested Border orchard, lead arsenate failed to control the codling moth.

The differences between Zinc and Copper Bordeaux were not important. Zinc sulfate and lime used in the first one or two cover sprays is an excellent corrective for arsenical injury. It is especially good when subsequent oil sprays are planned, since sulfur cannot be used and copper Bordeaux will cause russeting at this time of year.

The addition of apple sauce to lead arsenate schedules as an adjuvant failed to accomplish its purpose. The canned sauce was added to the schedule in order to induce newly hatched larvae to feed more freely on the foliage and on the fruit surface, thus reducing worm injury to the apple. Under West Virginia conditions the mixture soon dries and in all probability becomes unattractive to the larvae.

Tests in Biological-Mechanical Control Orchard

The biological-mechanical control project that had been conducted in the Cushwa orchard was terminated in 1942 after 8 years of infestation studies. In 1943 tests were arranged in this orchard to study the efficiency of the more important recommended spray schedules when applied to large blocks. The treatments were designed mainly for determining the relative efficiency of lime, zinc Bordeaux and copper Bordeaux as corrective for arsenical injury and their effect on the efficiency of arsenate of lead in codling moth control. It should be kept in mind that previously the orchard had received no codling moth cover sprays and presented a favorable situation for testing the relative effectiveness of spray schedules on a fairly sizeable scale. The tests were unreplicated, and were applied to single rows 13 to 16 trees long. Counts were made on at least 2 trees of each variety. The schedules tested and the results are summarized in table 2.

Table 2. Results of field experiments with insecticides for codling moth control. Cushwa Orchard, Kearneysville, West Virginia - 1943.

Treat- ment No.	Cov- ers	Materials 1/ (Amounts per 100 gal.)	Gano Variety: Average fruits per tree	Gano: Injuries per 100 fruits Worms	Gano: Injuries per 100 fruits Stings	Gano: Residues (gr. per pound of fruit) Lead	Gano: Residues Arsenic	York Variety: Average fruits per tree	York: Injuries per 100 fruits Worms	York: Injuries per 100 fruits Stings	York: Residues (gr. per pound of fruit) Lead	York: Residues Arsenic
1	1,4,5	LA 3#, L 3#										
	2,3	LA 3#, L 3# N 1 pt., O 1 gal.	898	35	98	.075	.035	1,249	7	70	.086	.035
2	1,5	LA 3#, L 3#										
	2	LA 3#, L 3#, N 1 pt.										
	3	LA 3#, L 3#, N 1 pt., O 1 gal.	2,308	10	46	.069	.028					
	4	LA 3#, L 3#, O 1 gal.										
3	1,4,5	Zn.Bord.1/4-1-100, LA 3#										
	2,3	Zn.Bord.1/4-1-100, LA 3#, N 1 pt., O 1 gal.	2,100	4	45	.084	.040	3,663	1	24	.114	.046
4	1,5	Zn.Bord.1/4-1-100, LA 3#										
	2	Zn.Bord.1/4-1-100, LA 3#, N 1 pt.										
	3	Zn.Bord.1/4-1-100, LA 3#, N 1 pt., O 1 gal.	1,800	5	45	.096	.041	1,904	7	90	.070	.037
	4	Zn.Bord.1/4-1-100, LA 3#, O 1 gal.										
5	1,4,5	Cu.Bord.1/4-1-100, LA 3#										
	2,3	Cu.Bord.1/4-1-100, LA 3#, N 1 pt., O 1 gal.	1,203	5	29	.090	.038	4,533	1	18	.108	.045
6	1,5	Cu.Bord.1/4-1-100, LA 3#										
	2	Cu.Bord.1/4-1-100, LA 3#, N 1 pt.										
	3	Cu.Bord.1/4-1-100, LA 3#, N 1 pt., O 1 gal.	1,551	4	17	.102	.036	1,352	5	52	.120	.049
	4	Cu.Bord.1/4-1-100, LA 3#, O 1 gal.										

1/ For footnote see next page.

1/ Table 2 - Footnote (Continued)

LA - lead arsenate	O - summer oil emulsion and lime
L - hydrated lime	Zn Bord. - zinc sulfate and lime
N - nicotine sulfate (40% nicotine)	Cu. Bord. - copper sulfate and lime.

Practically no arsenical injury appeared in any of the experiments. The addition of lime reduced the effectiveness of the spray materially below its effectiveness when zinc or copper bordeaux mixture was added to the spray. The slight difference between the zinc and copper sprays seemed to favor the copper material.

The remainder of the orchard was divided into two parts. One part received treatment 5--lead arsenate and bordeaux (copper) with nicotine and oil in the 2nd and 3rd sprays. The other part received treatment 6, which was the same as treatment 5, except that the oil was used in the 3rd and 4th instead of the 2nd and 3rd covers. The plot that received treatment No. 5 averaged 2,514 apples per tree with approximately 2 worms and 26 stings per 100 fruits, as compared with an average of 2,964 apples per tree with 2 worms and 34 stings per 100 fruits in the plot that received treatment 6.

Codling Moth Population Build-Up Studies

The object and methods of this study and of preliminary work undertaken were discussed in the annual pool of codling moth results for 1942, Part II, page 9. The work during 1942 was directed toward complete defruiting of the entire orchard in an attempt to completely eliminate the existing codling moth population. The work during the 1943 season was devoted mainly to studying the codling moth population build-up and the results of defruiting. A very limited spray schedule was followed during the season of 1943. It was planned so as to give the maximum control of diseases and miscellaneous insect pests with the minimum effect on codling moth.

A total of 5,000 fruits was examined for first brood infestation. Of this number only 18 (0.36%) showed codling moth entries. A total of 21 entries were found: 13 of these were very shallow and showed no evidence of having contained codling moth larvae; 6 contained live larvae at the time of the examination; 4 were reared out and proved to be codling moth larvae; and the other 2 entries were large and deep but not typical of codling moth entries. Thus only 4 of the 5,000 fruits examined for first brood injury definitely produced codling moths. This light carry-over may have resulted from infestation that developed in the few fruits which in all probability were missed during the season of 1942. It may, however, have resulted

from some other source. It is of interest that, although the infestation or carry-over was exceedingly light, it was evenly distributed over the entire orchard.

The results obtained from 25 count trees in 1943 are compared below with the records from these same trees during 1941:

Year	Yield 1/ Total fruits	Bushels	Average fruits per bushel	Pre-harvest drops	Injuries per 100 fruits Worms	Stings
	number	number	number	percent	number	number
1941	106,908	341	284	51.6	55	19
1943	36,557	171	212	19.0	9	9

1/ Includes dropped and picked fruits.

From the standpoint of codling moth control the results from this experiment are quite gratifying but further studies are needed to develop a more satisfactory method for defruiting the trees. A number of limited tests were made during 1943 to obtain information as to potential materials which might be substituted for the DNOCHP-Oil treatment used for defruiting without the drastic effect on the trees. Elgetol and Dn-111 both show promise of being very effective when used in full bloom but thorough coverage is very difficult at this stage of development. It appears that a satisfactory material must be one which can be used effectively when thorough coverage can be obtained the easiest.